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TOWED THERMISTOR CHAIN OBSERVATIONS DURING MILE.(U)
JUL 79 T J SPOERING, C A PAULSON, D DENBO N00014-76-C-0067
UNCLASSIFIED DATA-74 NL

1 OF 2
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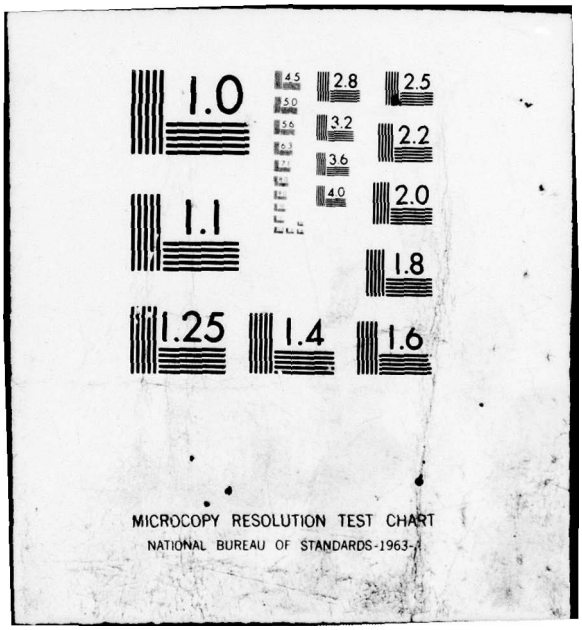
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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OCEANOGRAPHY

LEVEL II

Towed Thermistor Chain Observations During MILE

by

T. J. Spoering
C. A. Paulson
D. Denbo
and
J. Wagner

Office of Naval Research
N00014-78-C-0097
N00014-78-C-0094
NR 083-102

Data Report 74 Reference 79-11
July 1979

OREGON STATE UNIVERSITY

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 79-11
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): TOWED THERMISTOR CHAIN OBSERVATIONS DURING MILE
5. TYPE OF REPORT & PERIOD COVERED: Data rept.
6. PERFORMING ORG. REPORT NUMBER: Data Report No. 74

7. AUTHOR(s): T. J. Spoering, C. A. Paulson, D. Denbo and J. Wagner
8. CONTRACT OR GRANT NUMBER(s): N00014-76-C-0067, N00014-79-C-0004

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
School of Oceanography
Oregon State University
Corvallis, OR 97331

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NR 083-102

11. CONTROLLING OFFICE NAME AND ADDRESS:
Office of Naval Research
Ocean Science and Technology Division
Arlington, VA 22217

12. REPORT DATE: July 1979
13. NUMBER OF PAGES: 101

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 106p.

15. SECURITY CLASS. (of this report): unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

DATA-74
REF-79-11

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Towed Therimistor Chain
Horizontal Temperature Variability
Isotherm Cross-sections
Mixed Layer Experiment (MILE)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Observations of temperature between 20 and 40 m depth were made with a towed thermistor chain in the North Pacific (50N, 145W) during the Mixed Layer Experiment (MILE). The chain was usually towed at a speed of 3 m/s around a 20 km square on alternate days for a three-week period beginning on 20 August 1977. The observations were averaged over sequential 30-second intervals and isotherm depths were interpolated from the averaged observations. Plots of temperature and isotherm depth are presented. The plots show the horizontal variability of temperature in the well-mixed layer and the vertical displacement

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S/N 0102-014-6601

Unclassified

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272 268

of isotherms induced by internal waves in the thermocline.

TOWED THERMISTOR CHAIN

OBSERVATIONS DURING MILE

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Oregon State University
Corvallis, Oregon 97331

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Dean

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Office of Naval Research
Contract N00014-76-C-0067
and N00014-79-C-0004
Project NR 083-102

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ACKNOWLEDGMENTS

The design and construction of the thermistor chain were carried out by the Technical Planning and Development Group at Oregon State University under the direction of Rod Mesecar. The cooperation of the officers and crew of the NOAA ship OCEANOGRAPHER, Captain George Poor commanding, is gratefully acknowledged. This research was supported by the Office of Naval Research through contracts N00014-76-C-0067 and N00014-79-C-0004 under Project NR 083-102.

TABLE OF CONTENTS

INTRODUCTION

This report presents observations of temperature in the upper ocean obtained with a towed thermistor chain as a part of the Mixed Layer Experiment (MILE). The observations were taken between 20 and 40 m depth in the vicinity of Ocean Station P (50N, 145W) during August and September 1977. The thermistor chain was towed by the NOAA Ship OCEANOGRAPHER.

The temperature observations have been analyzed by Spoering (1979) to show the characteristics of internal waves in the upper ocean. Spoering's report also contains additional descriptions of the instrumentation, observations and analysis.

INSTRUMENTATION

The thermistor chain was constructed of sensors, conductors, plastic fairing, a strain member and a 450 kg. depressor. The thermistors were installed at 1 m intervals over a 25 m section of the chain. Four pressure sensors were installed at intervals of 8 m. The 450 kg. lead-filled depressor was attached to the lower end of the chain. The angle between the chain and the vertical was less than 10^{o} for tow speeds up to 3 m/s with the depressor at a depth of 40 m. Signals from the sensors were recorded and displayed aboard ship by use of a minicomputer system.

OBSERVATIONS

The thermistor chain was usually towed on alternate days around a 20 km square. The tow tracks and times are presented in Appendix A. The tow beginning on 5 September proceeded four times around a five-km square centered on a heavily instrumented mooring. The tow tracks and speeds were determined from satellite fixes, radar fixes on the moorings and dead reckoning. During tows, the ships heading and speed were maintained as constant as possible on each leg. The tow speed ranged from 1 to 3 m/s and usually was greater than 2 m/s.

The structure of the upper ocean and the meteorological conditions were characteristic of mid-latitudes during late summer. The upper 30 m of the ocean was usually well-mixed or weakly stratified, bounded below by

a layer of large temperature gradient. Winds during the experiment ranged from near calm to 20 m/s. Wind speeds during tows of the thermistor chain ranged up to 12 m/s.

The only disappointment in the performance of the thermistor chain system was the failure of many of the temperature sensors. The failures were caused by saltwater leaks into the potting between the thermistors and the pad resistors and by leaks through the glass coatings of the thermistor. As a result of these failures only 4 to 10 thermistors were functional at any one time. The operational thermistors were concentrated in one section of the chain. This section was normally centered at a depth of about 30 m, in and above the region of high stratification.

ANALYSIS

The temperature observations were low-pass filtered by computing sequential 30 s averages. The filtered observations were edited to remove effects of radio noise and other errors. These filtered and edited observations are shown in Appendix B as functions of time and distance during a tow.

Isotherm depths were determined by linear interpolation between the filtered temperature observations. The depths of isotherms at spacings of 0.5°C are shown in Appendix C as functions of time and distance during a tow. Some of the tows are also plotted with a 1.0°C spacing in Appendix D.

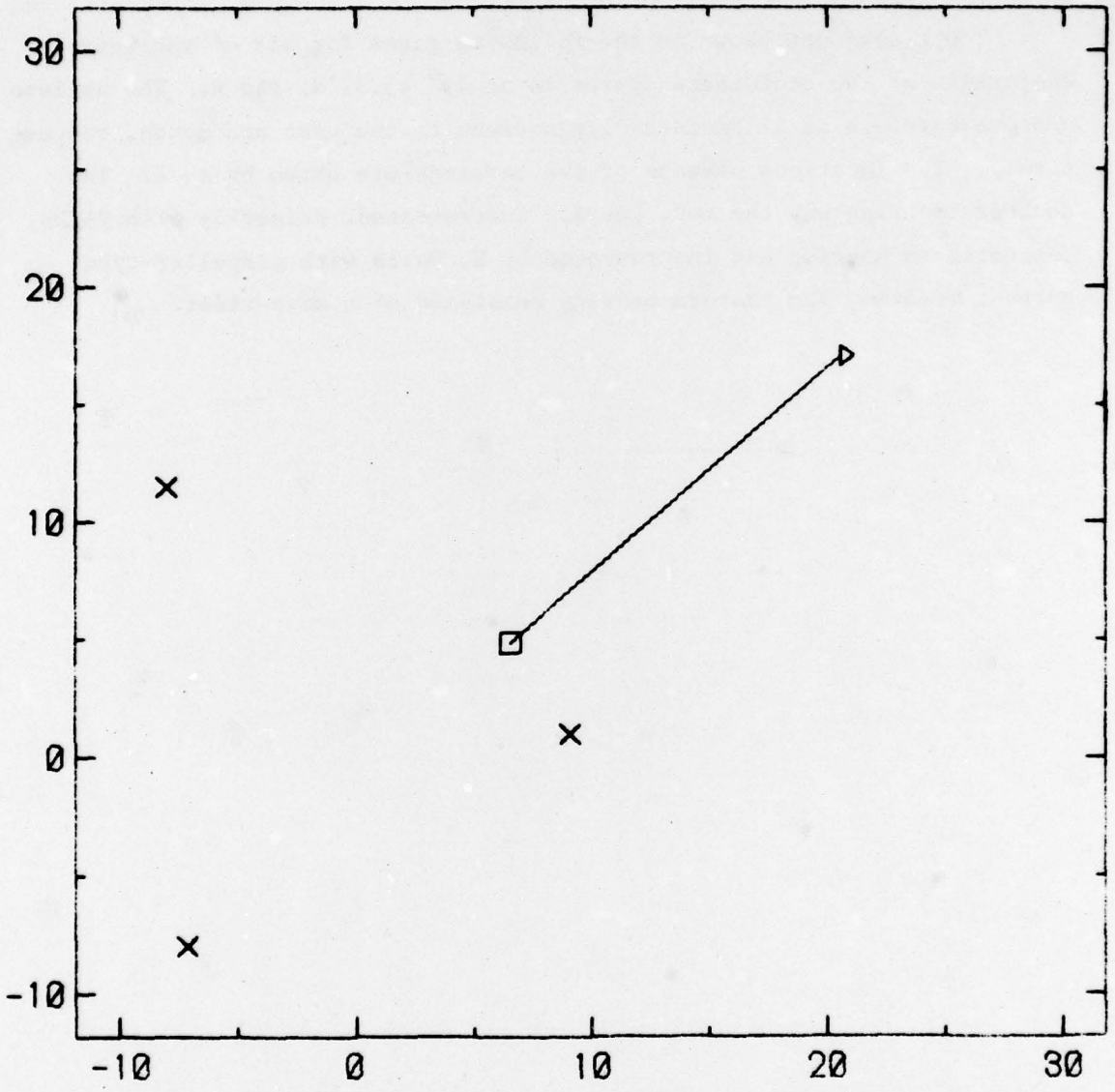
REFERENCES

Spoering, T. J., 1979: Towed observations of internal waves in the upper ocean. Report 79-10, School of Oceanography, Oregon State University, Corvallis, OR 97331, 121 pp.

APPENDIX A

Tow Tracks

Tow tracks are shown on the following pages for all of the runs. The origin of the coordinate system is at 49° 43.31'N, 145 W. The abcissa and ordinate are in kilometers displacement to the east and north, respectively. The locations of each of the moorings are shown by an X. The southern mooring was the most heavily instrumented, primarily with VACMs. The northern mooring was instrumented by R. Davis with propeller-type current meters. The eastern mooring consisted of a wave-rider.



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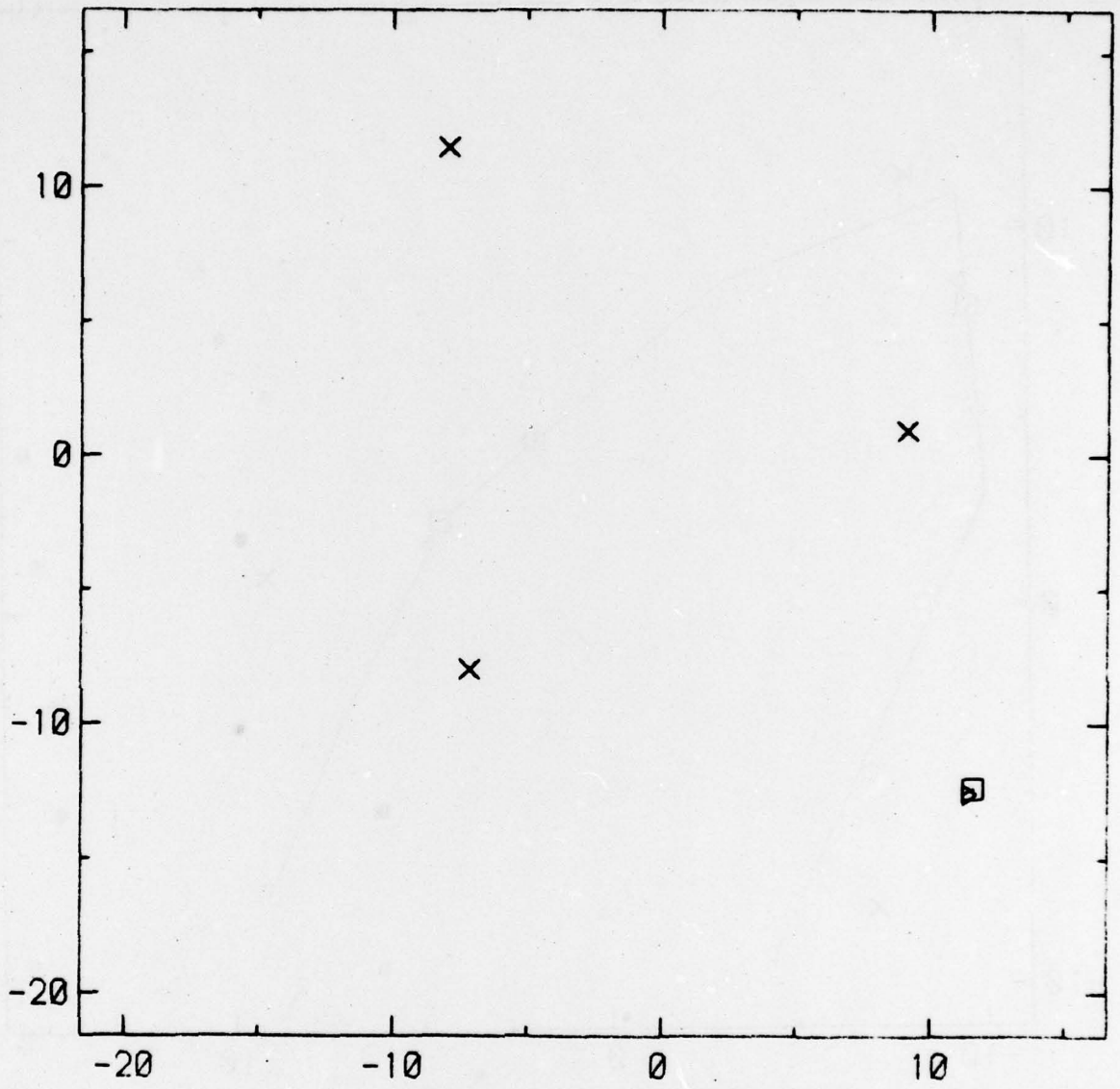

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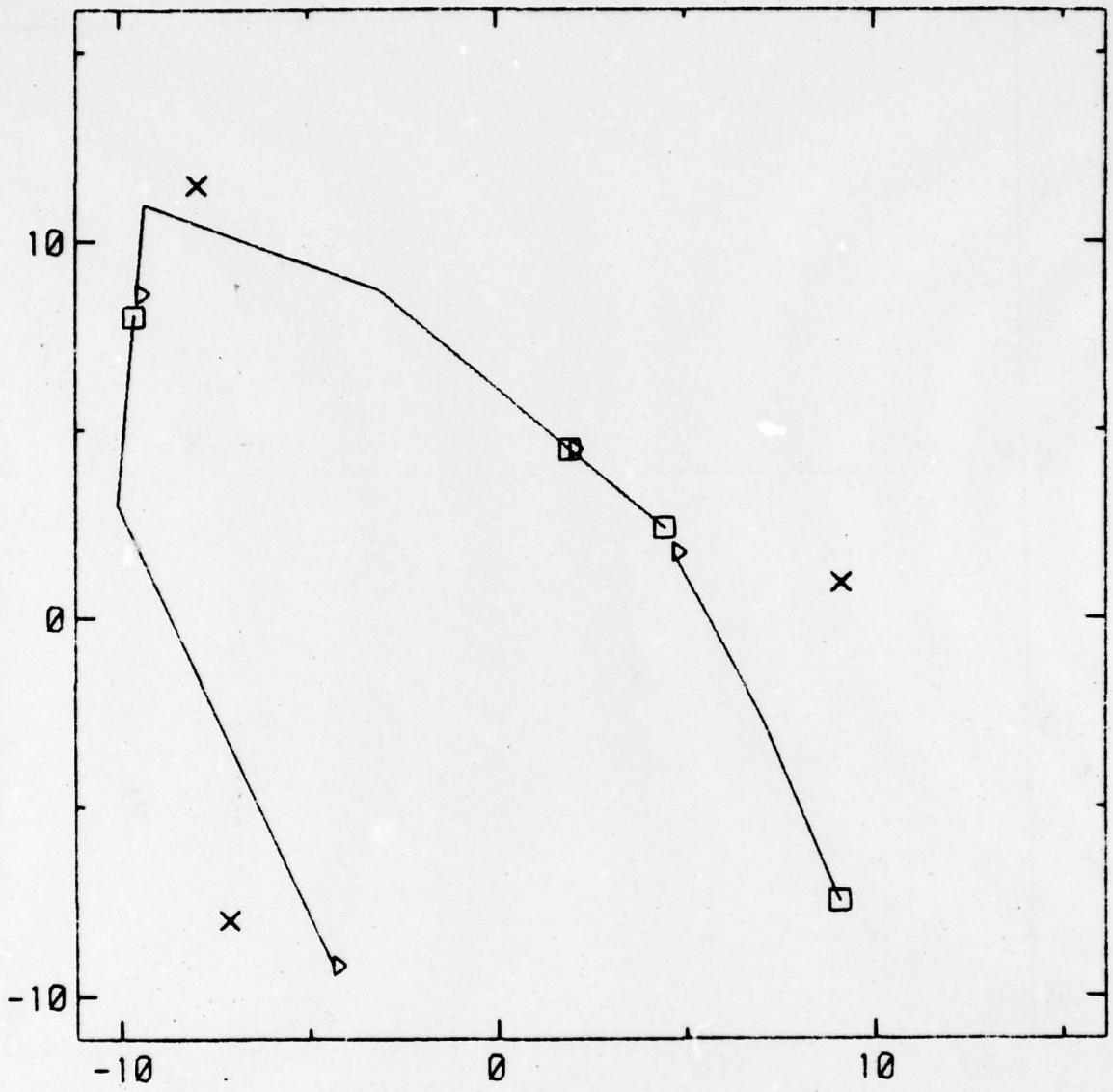

24 AUG 77 TOW TRACKS (KM)
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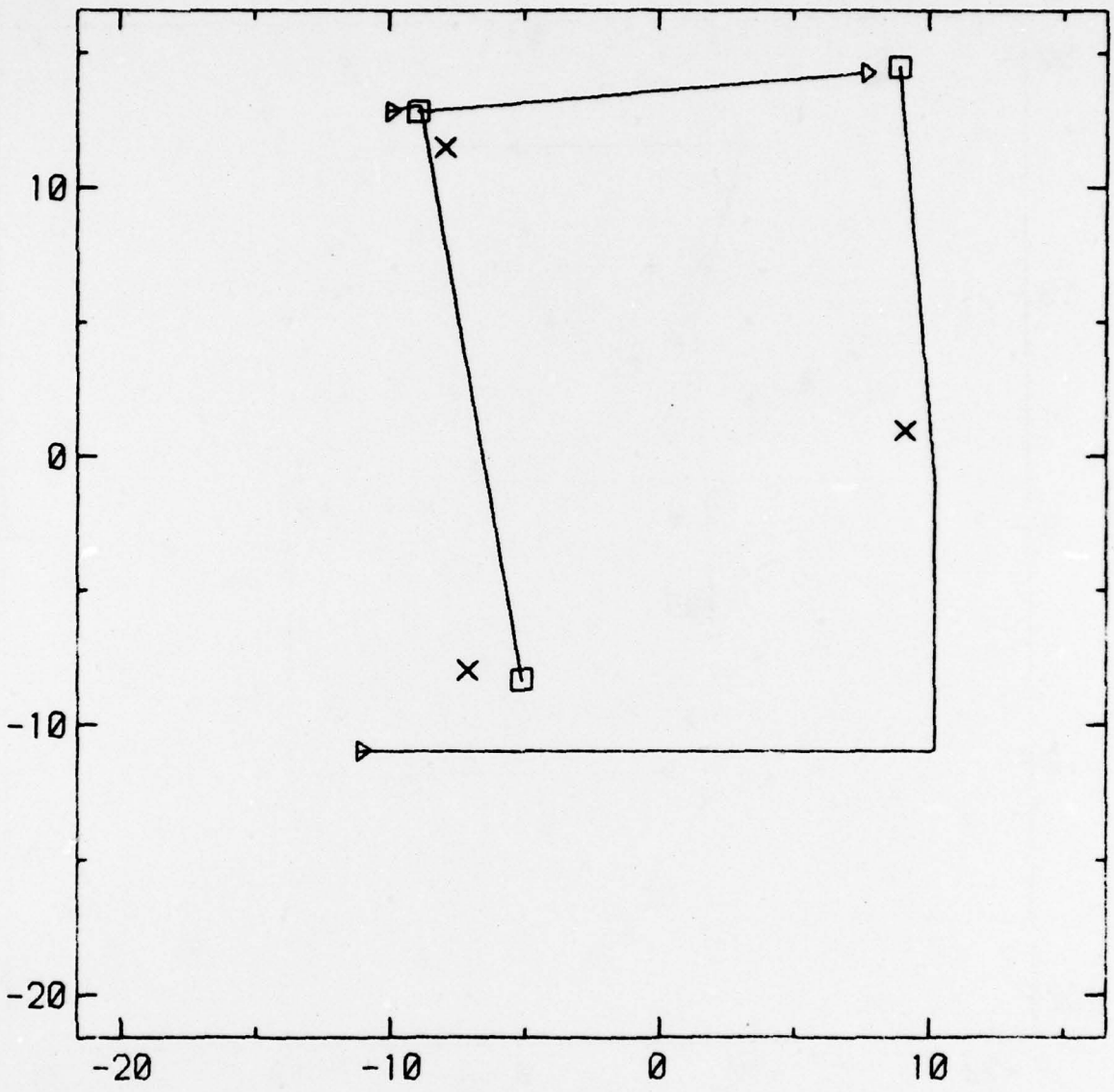

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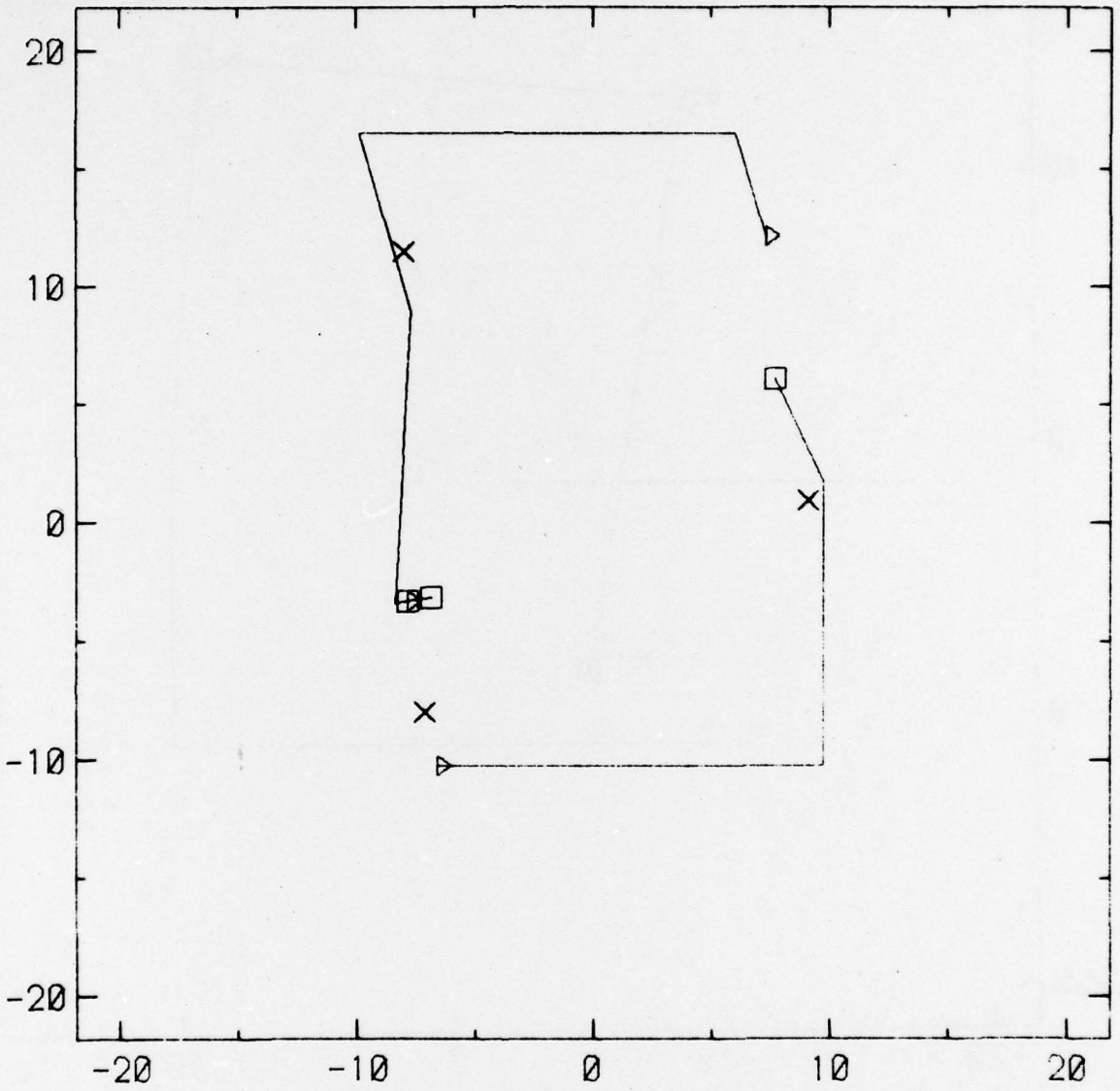

28-29 AUG 77 TOW TRACKS (KM)

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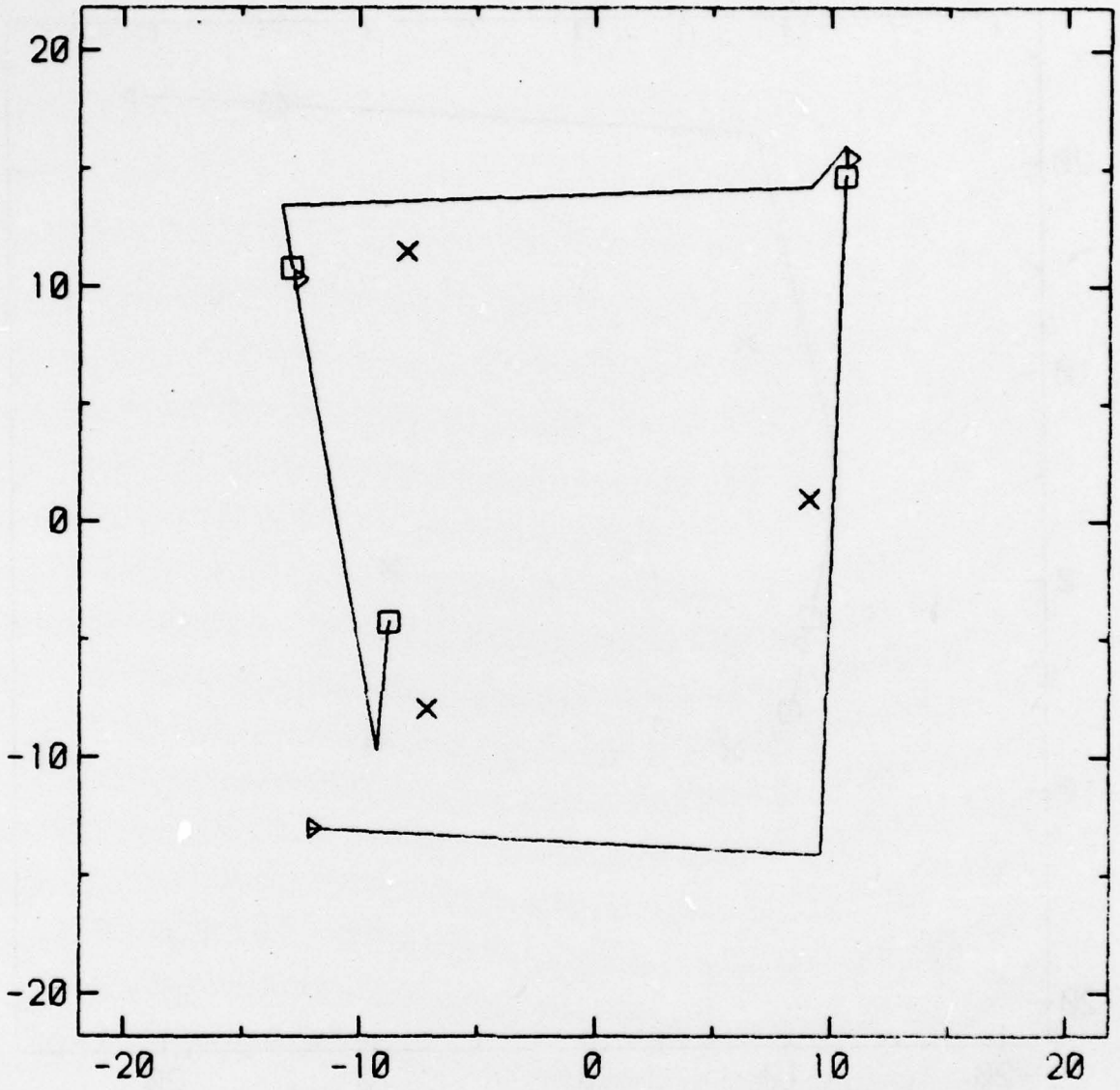

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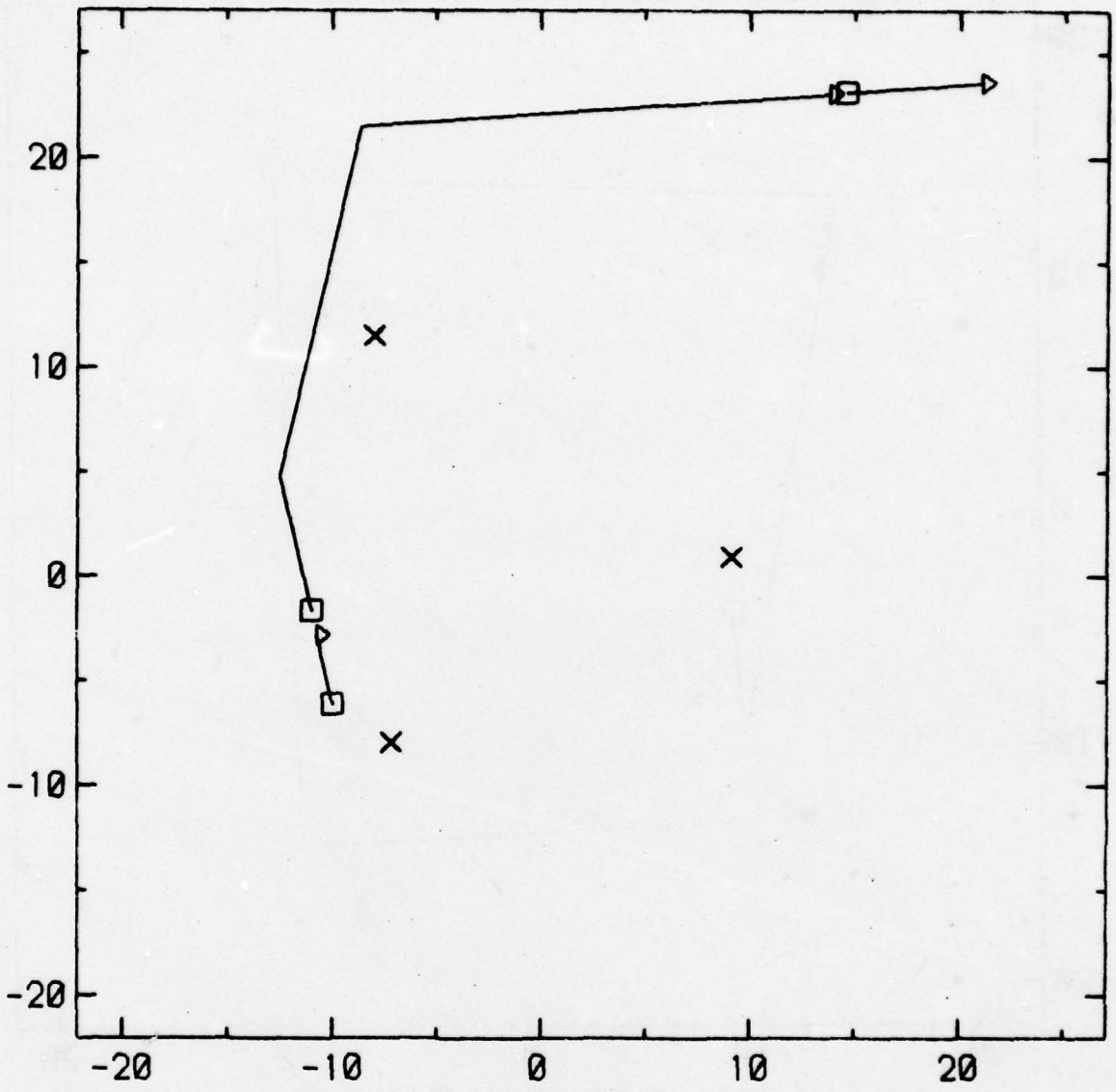

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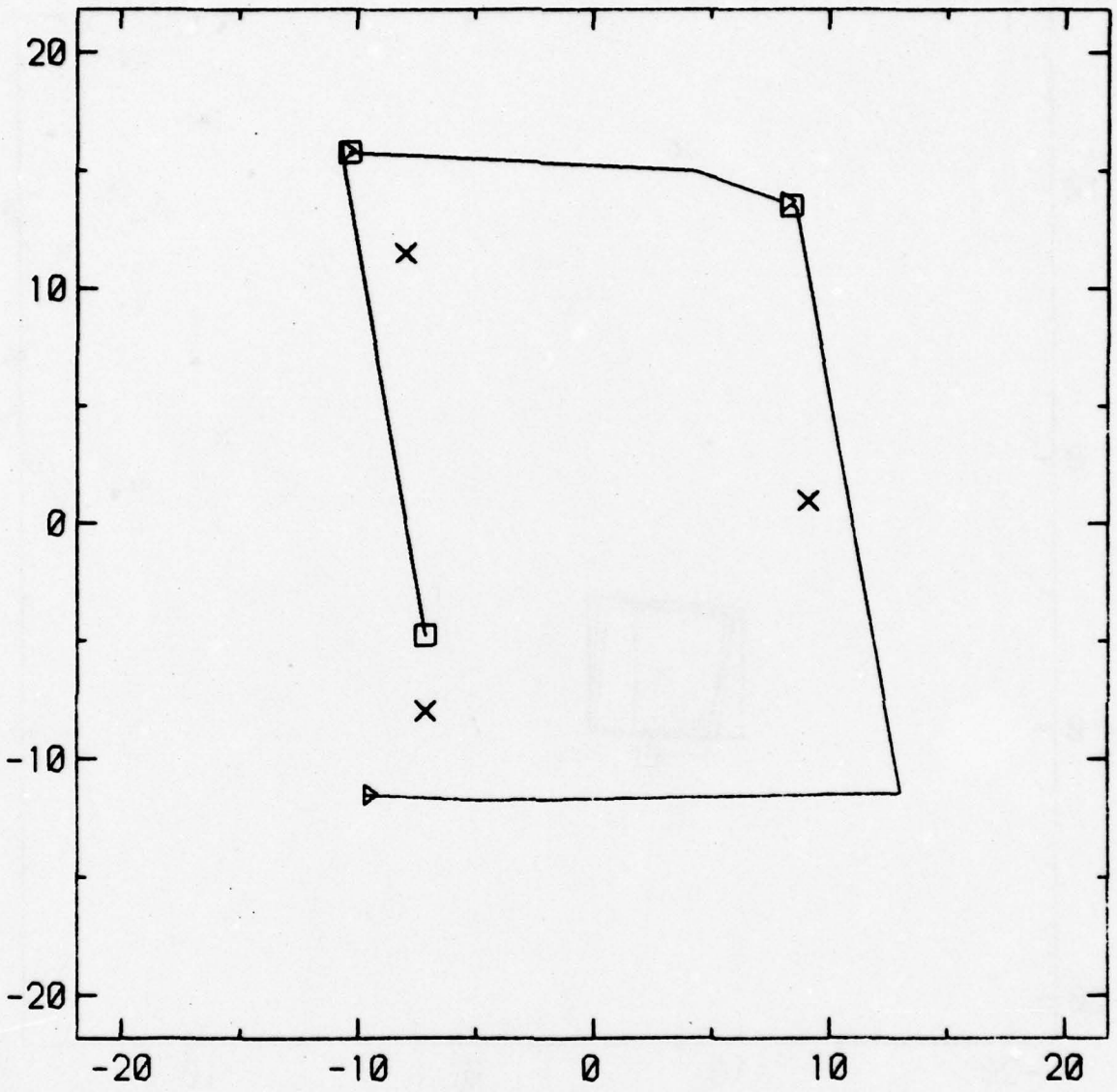

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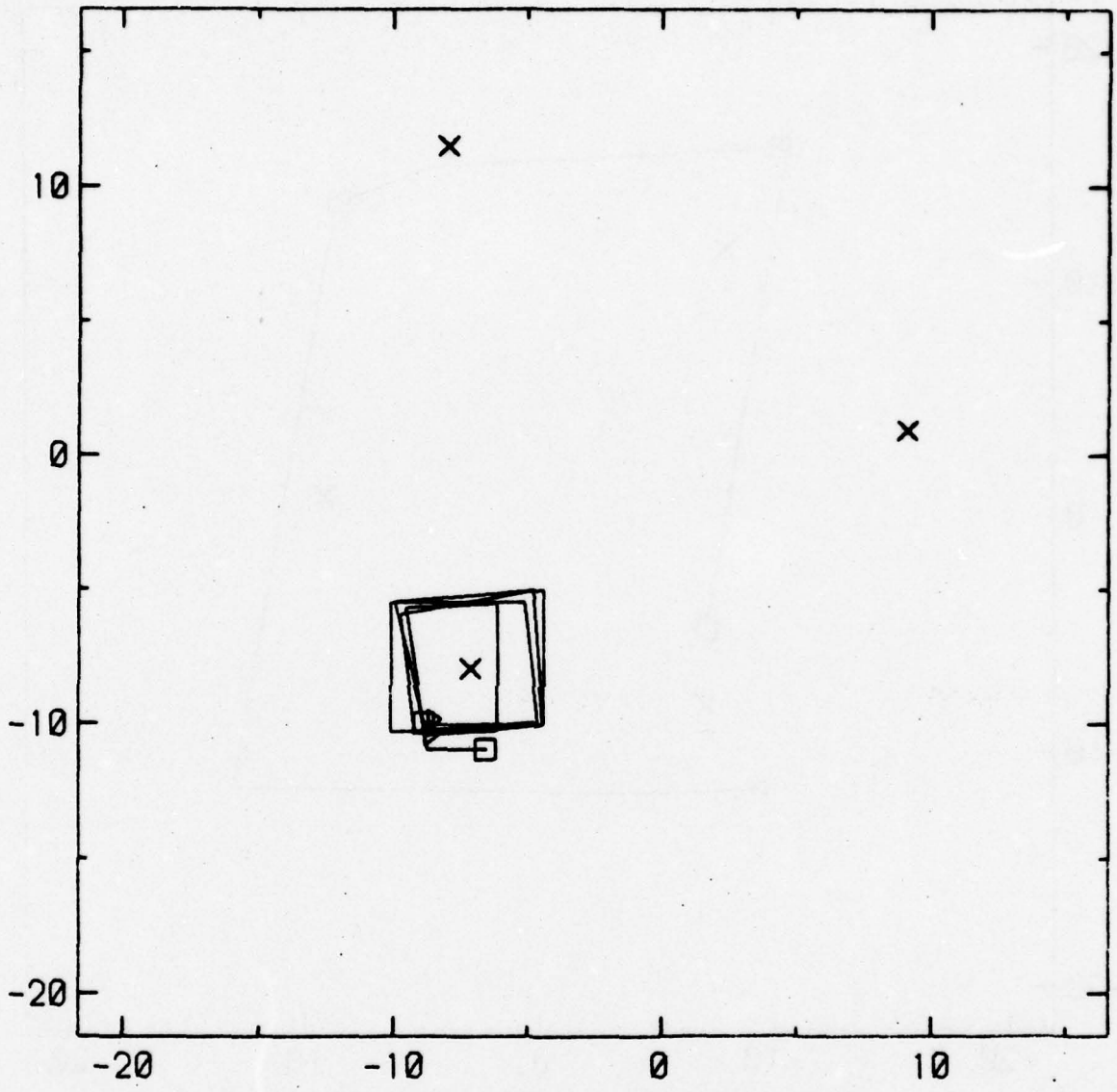

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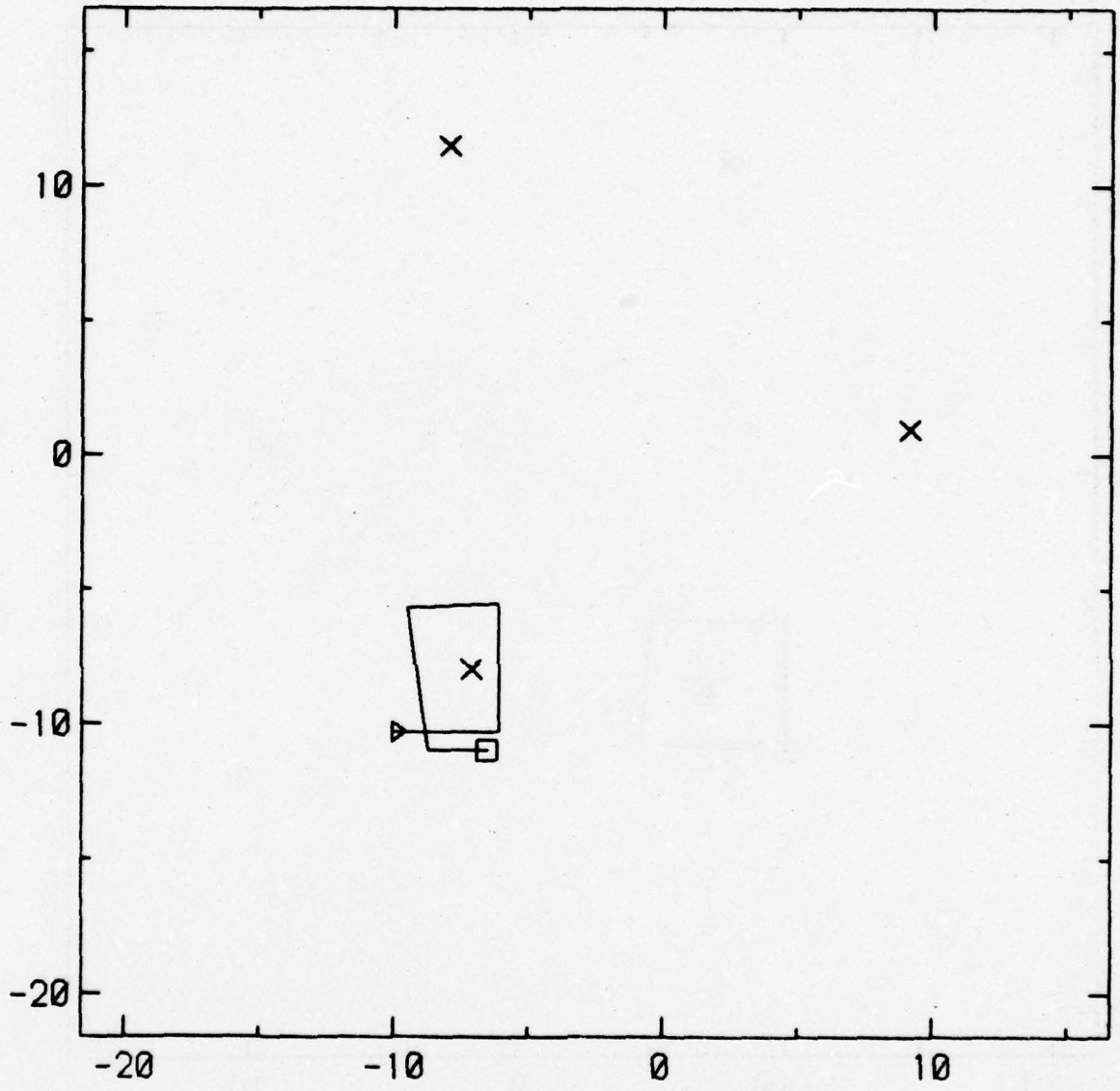

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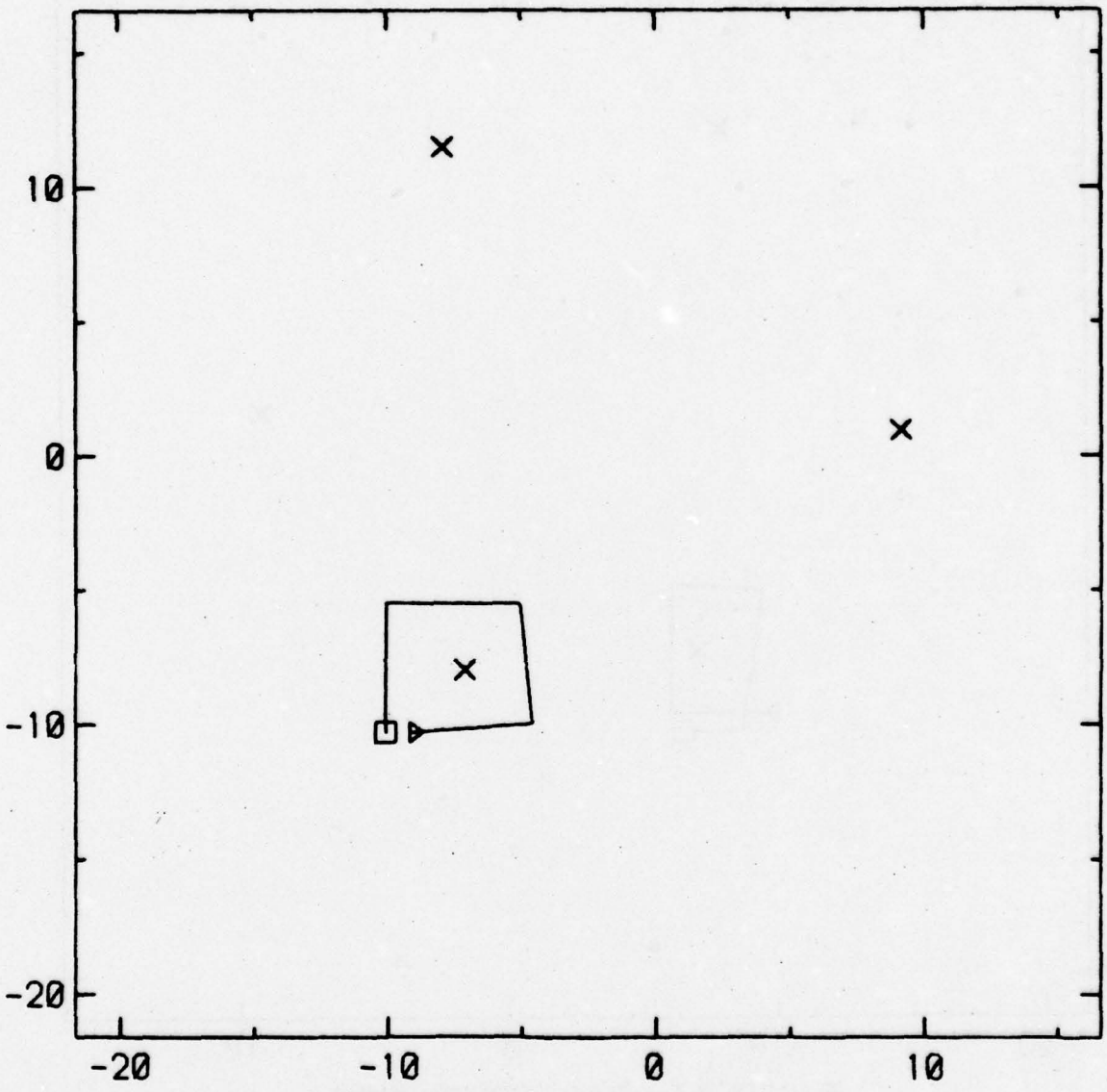

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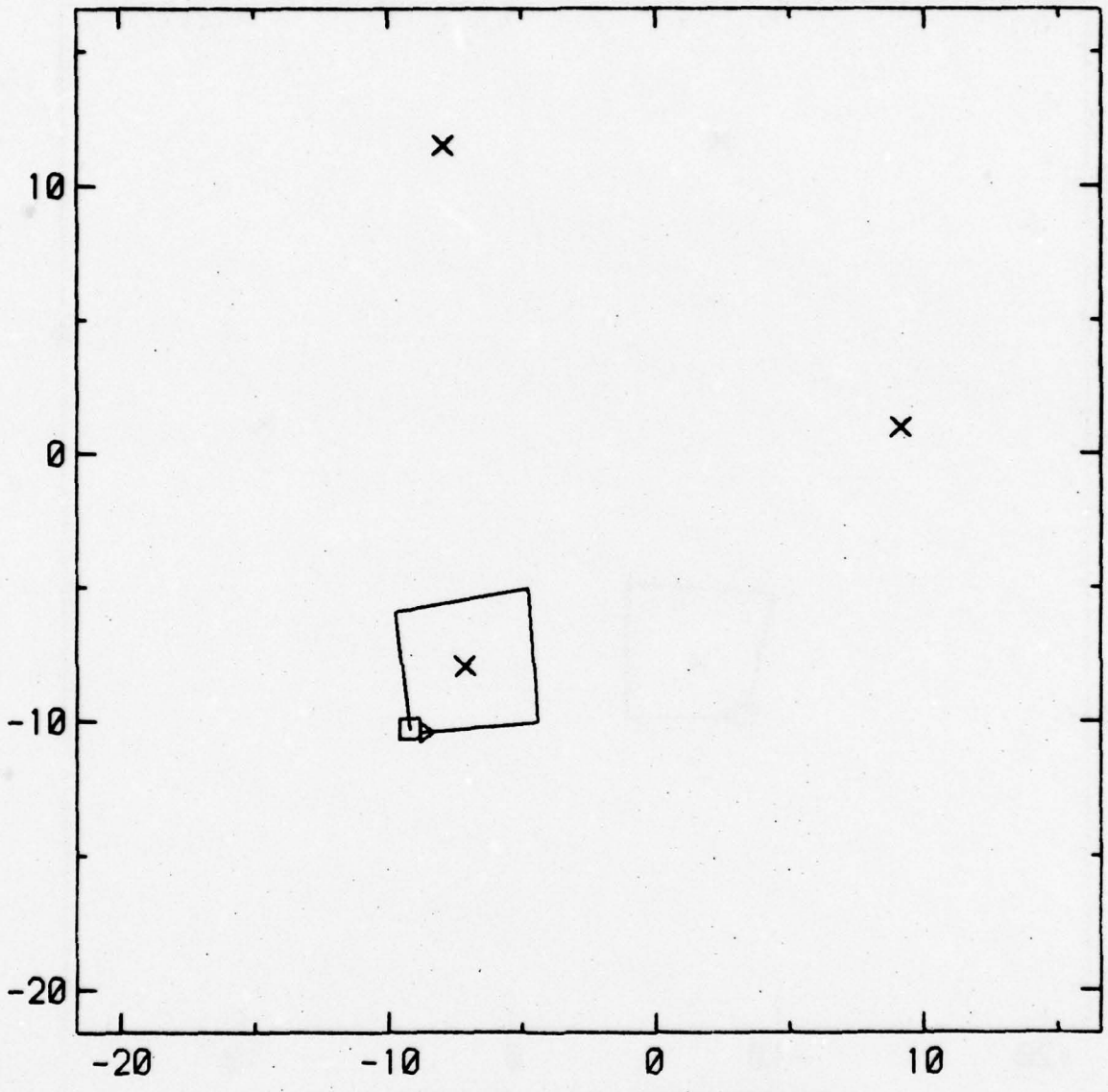

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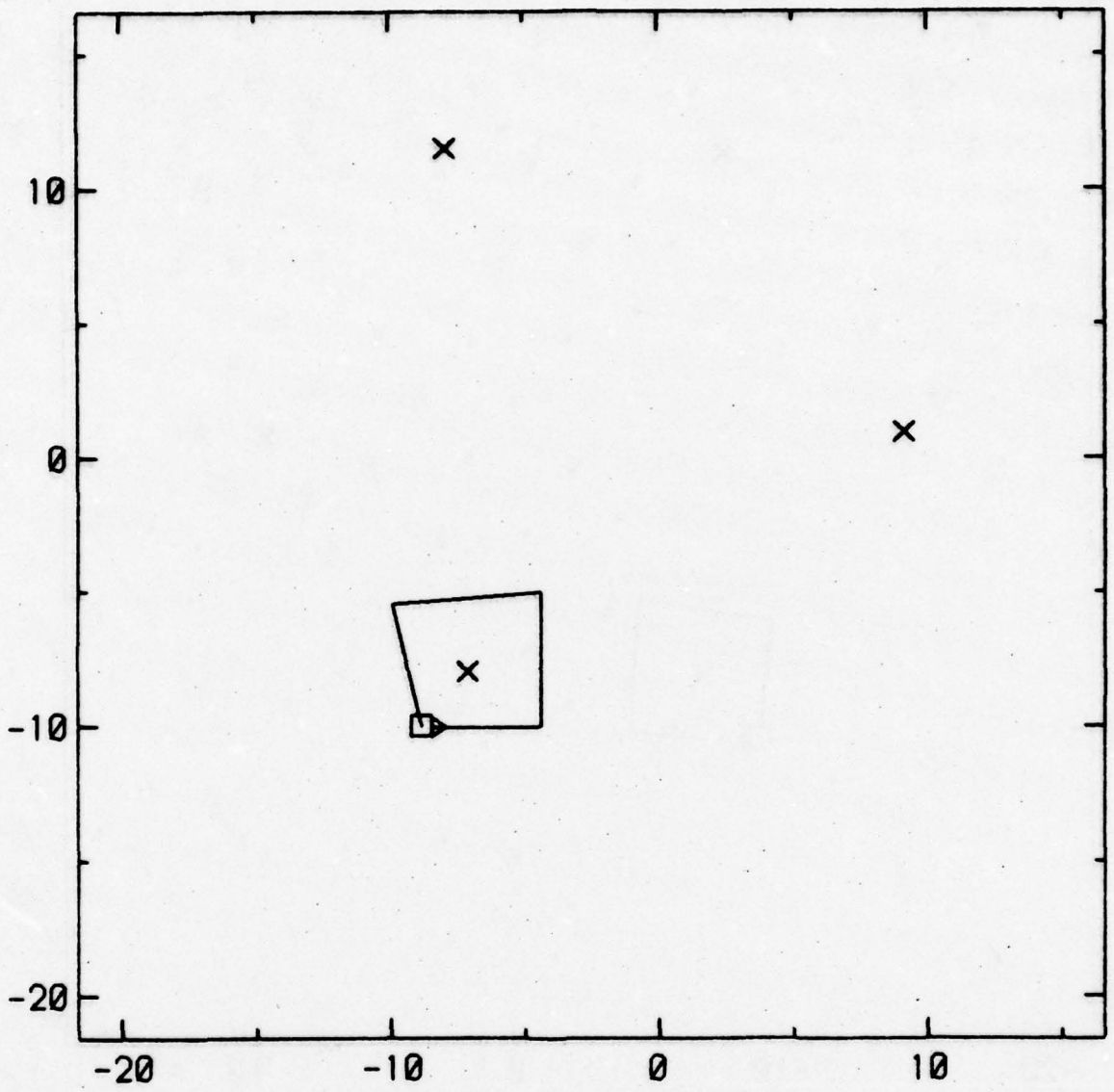

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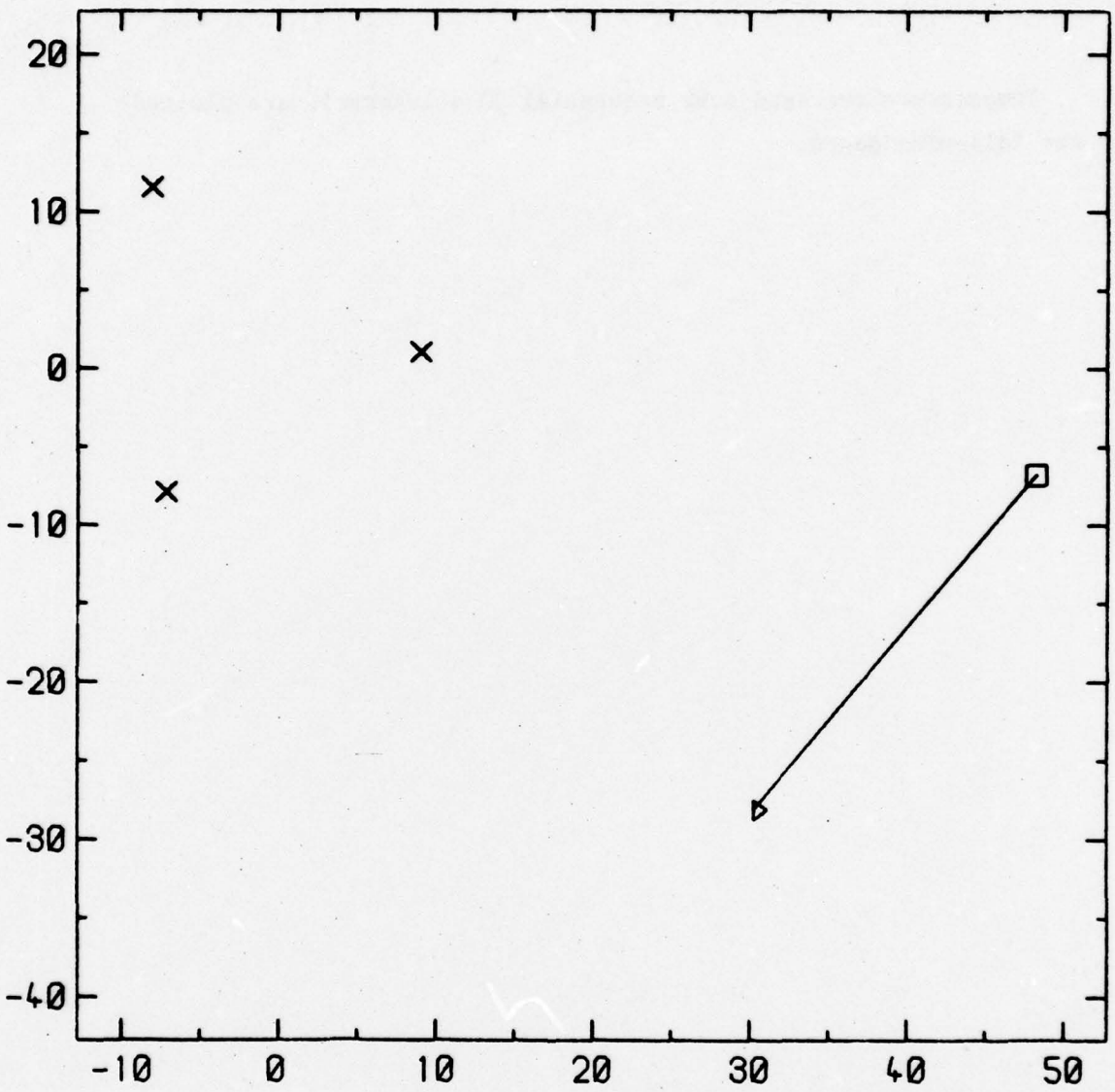

8 SEP 77 TOW TRACKS (KM)

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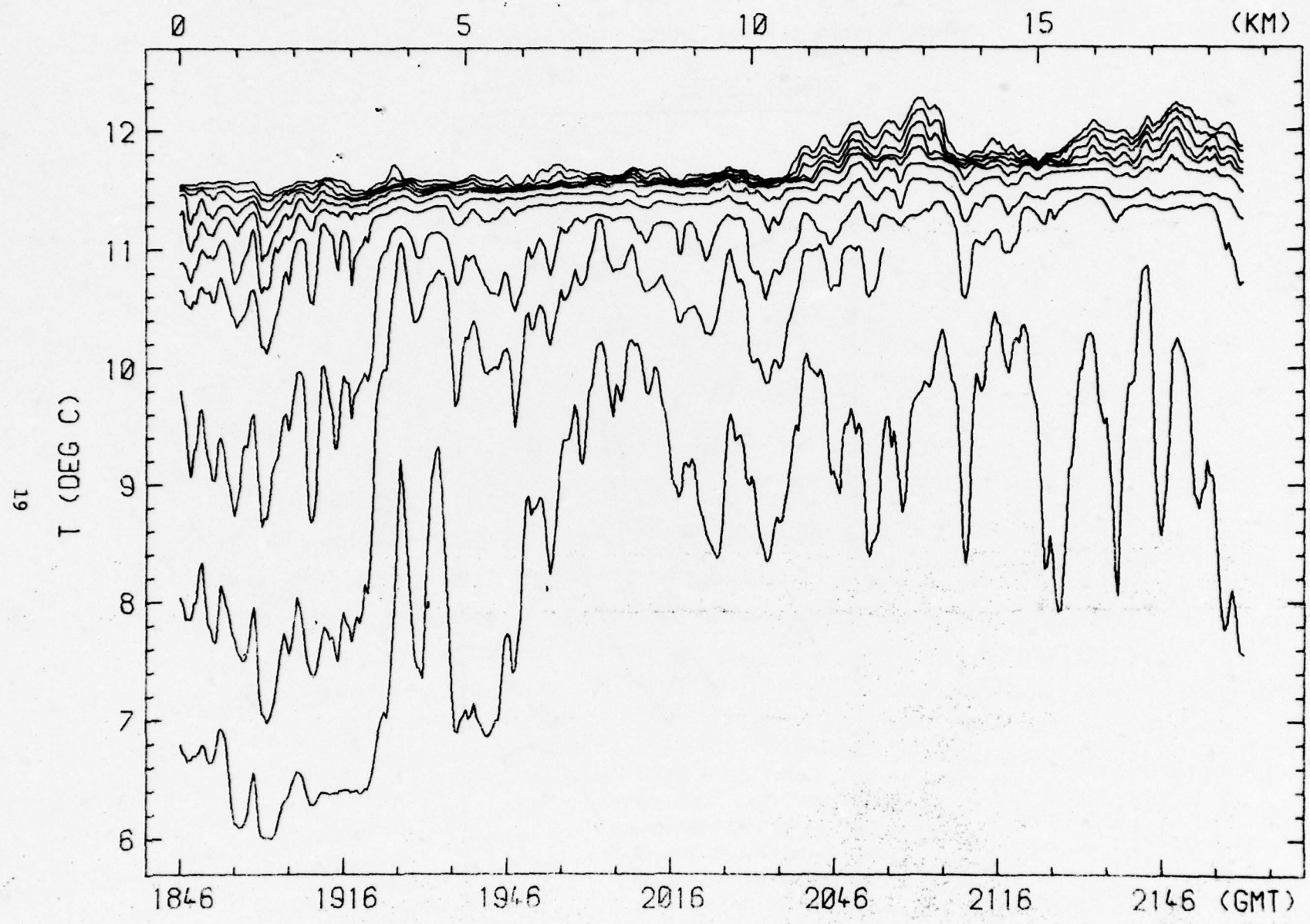
□: BEGINNING ▷: END ×: MOORING

APPENDIX B

Temperature Cross-sections

Temperature averaged over sequential 30 s intervals are plotted on the following pages.



RUN 01 20 AUG 77 TEMP VS TIME/DISTANCE

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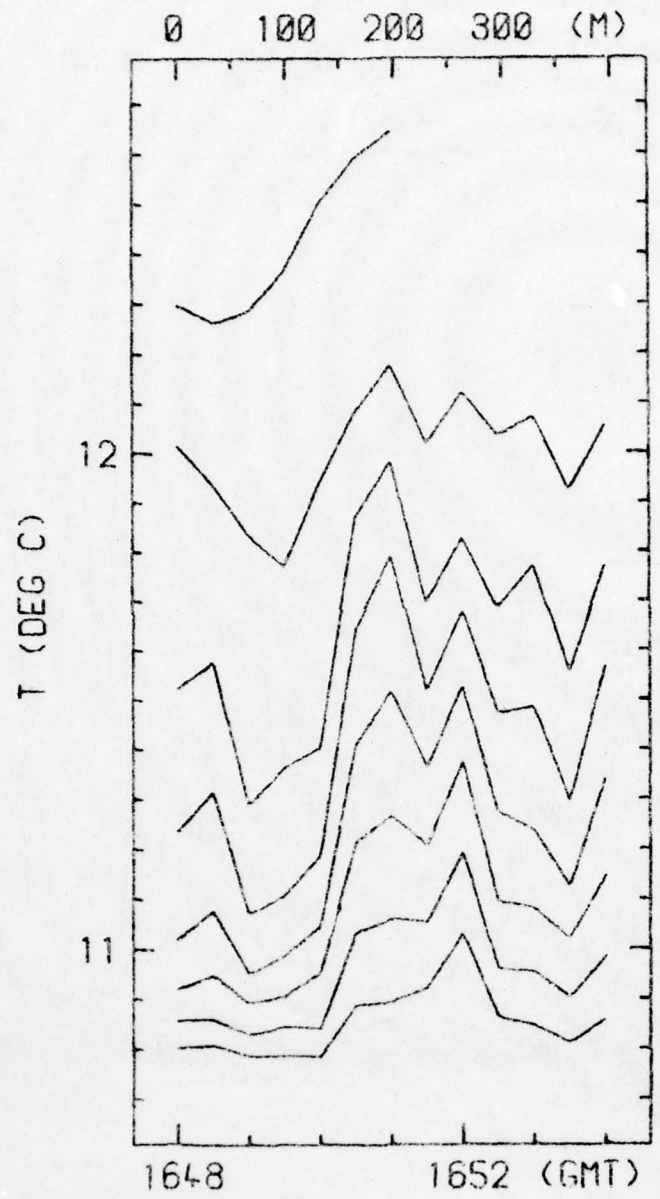

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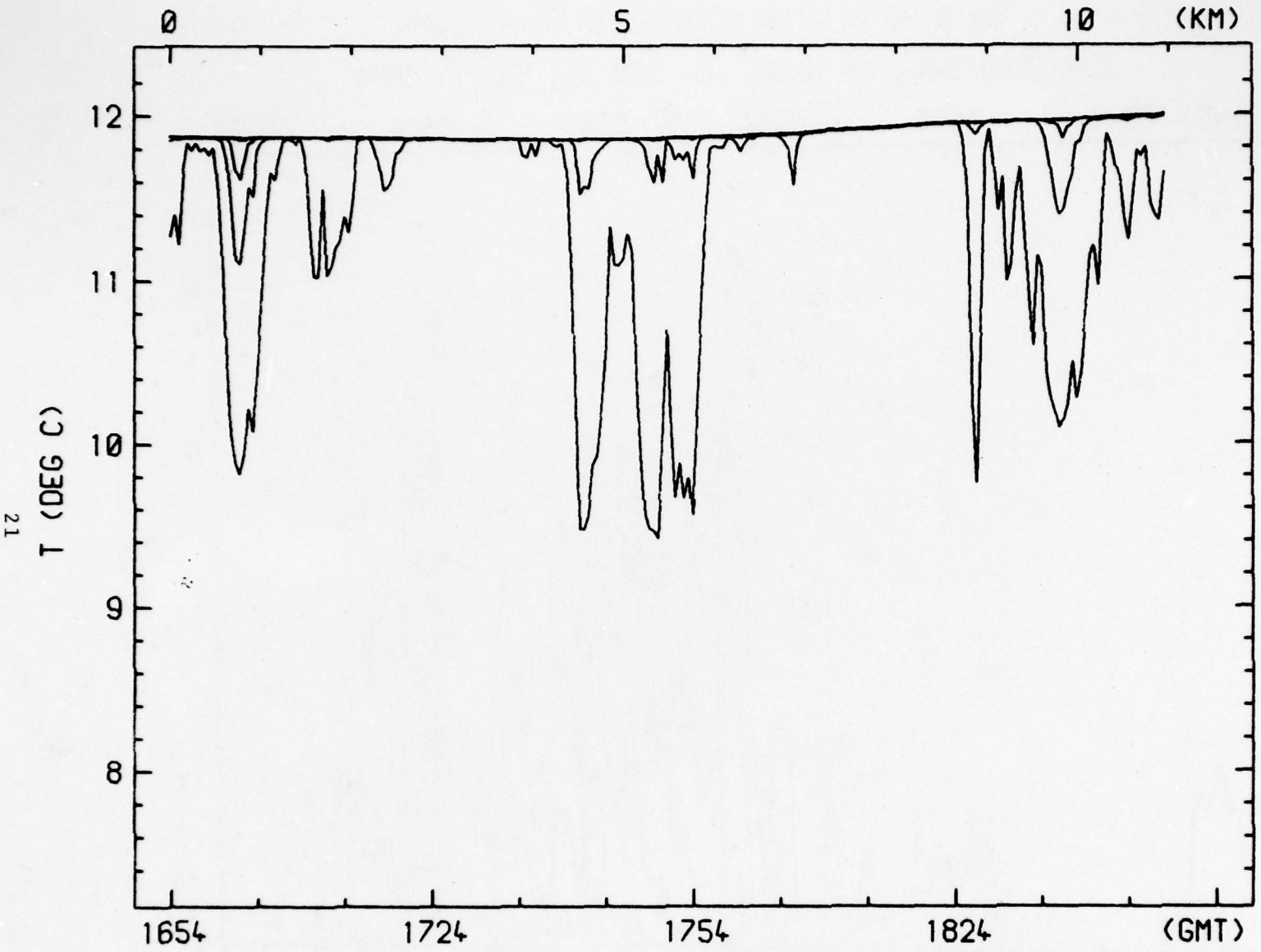

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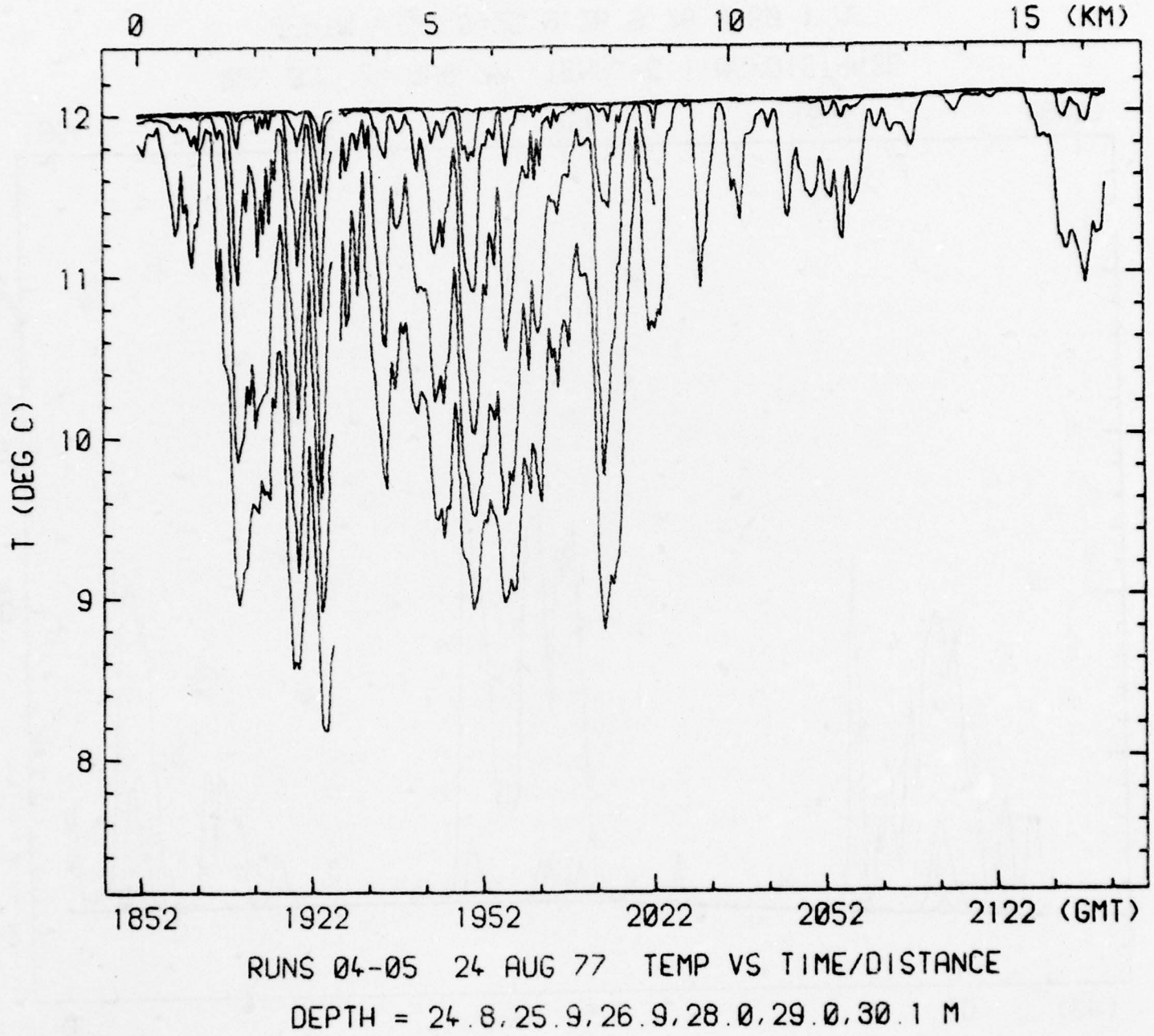
0
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T (DEG C)
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1922
1952
2022
2052
2122 (GMT)
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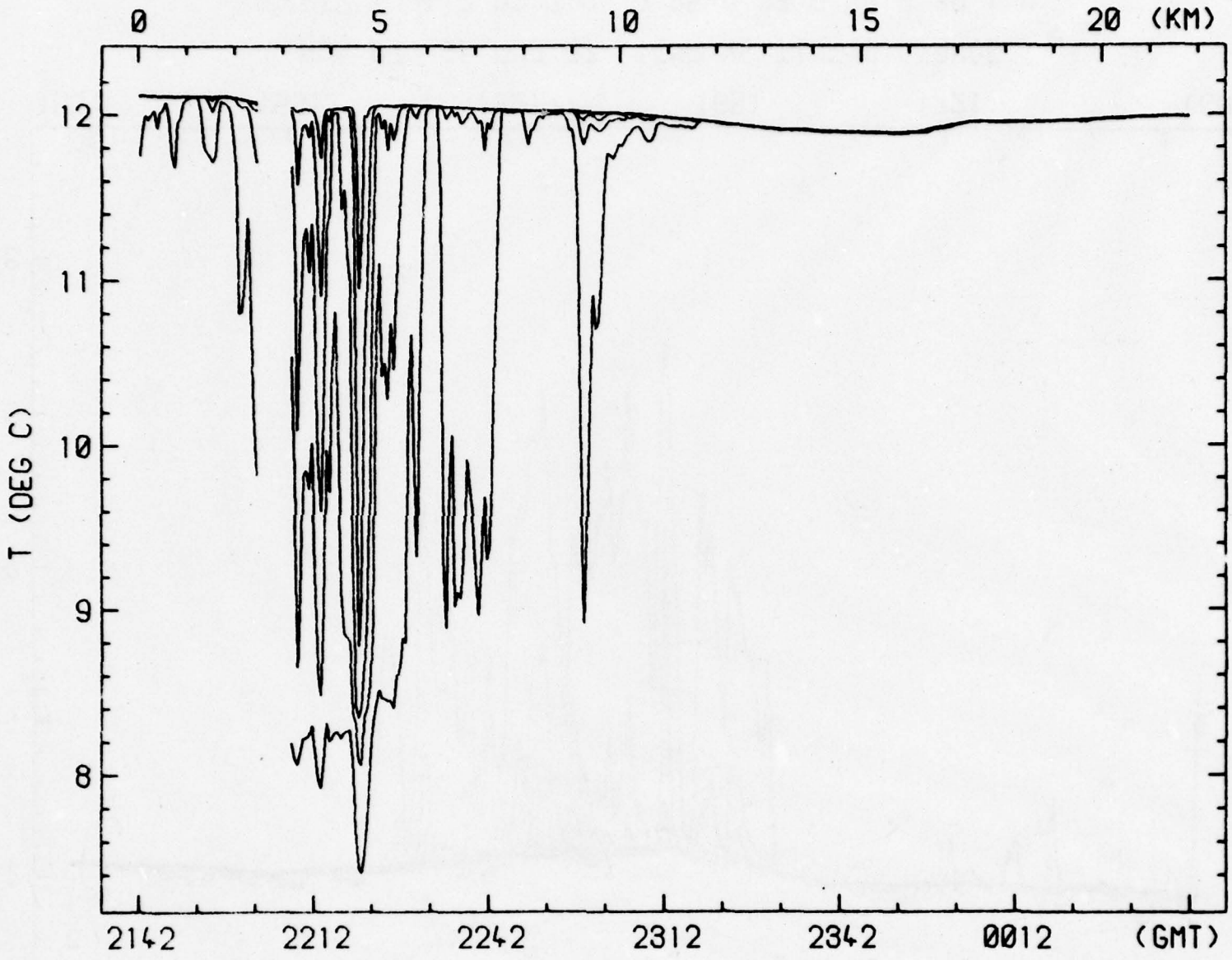

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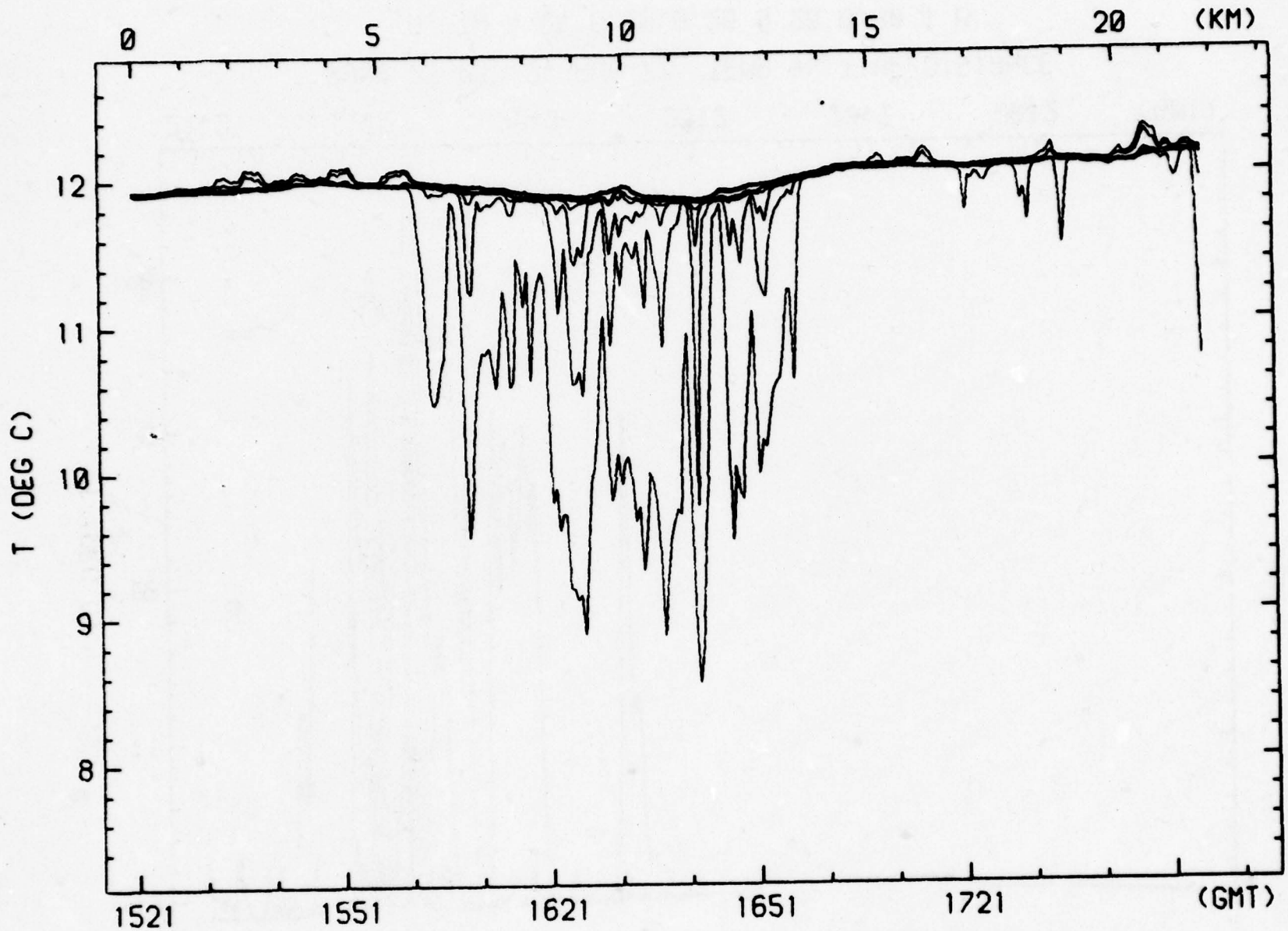

RUN 07 26 AUG 77 TEMP VS TIME/DISTANCE

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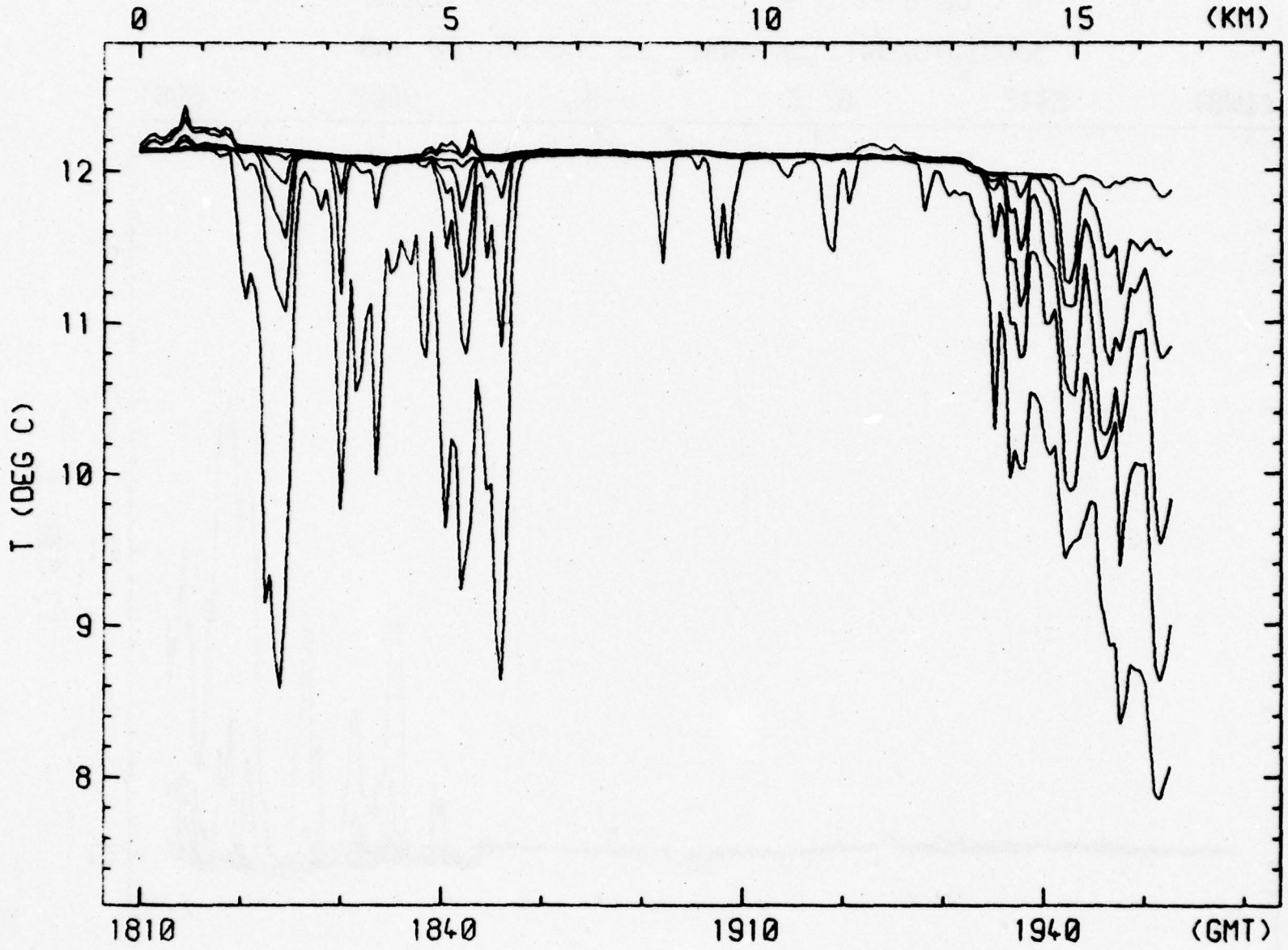
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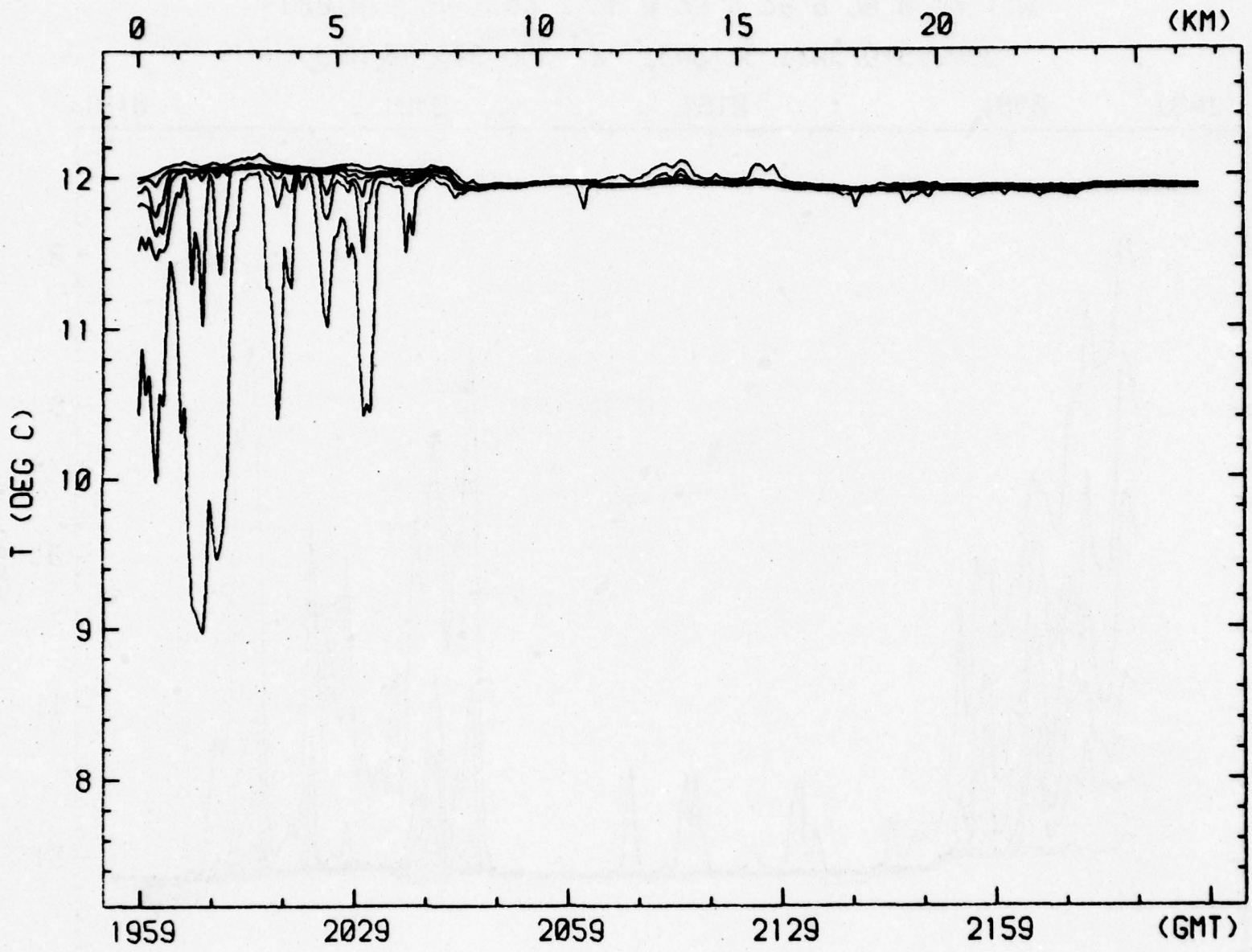
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RUN 09 26 AUG 77 TEMP VS TIME/DISTANCE
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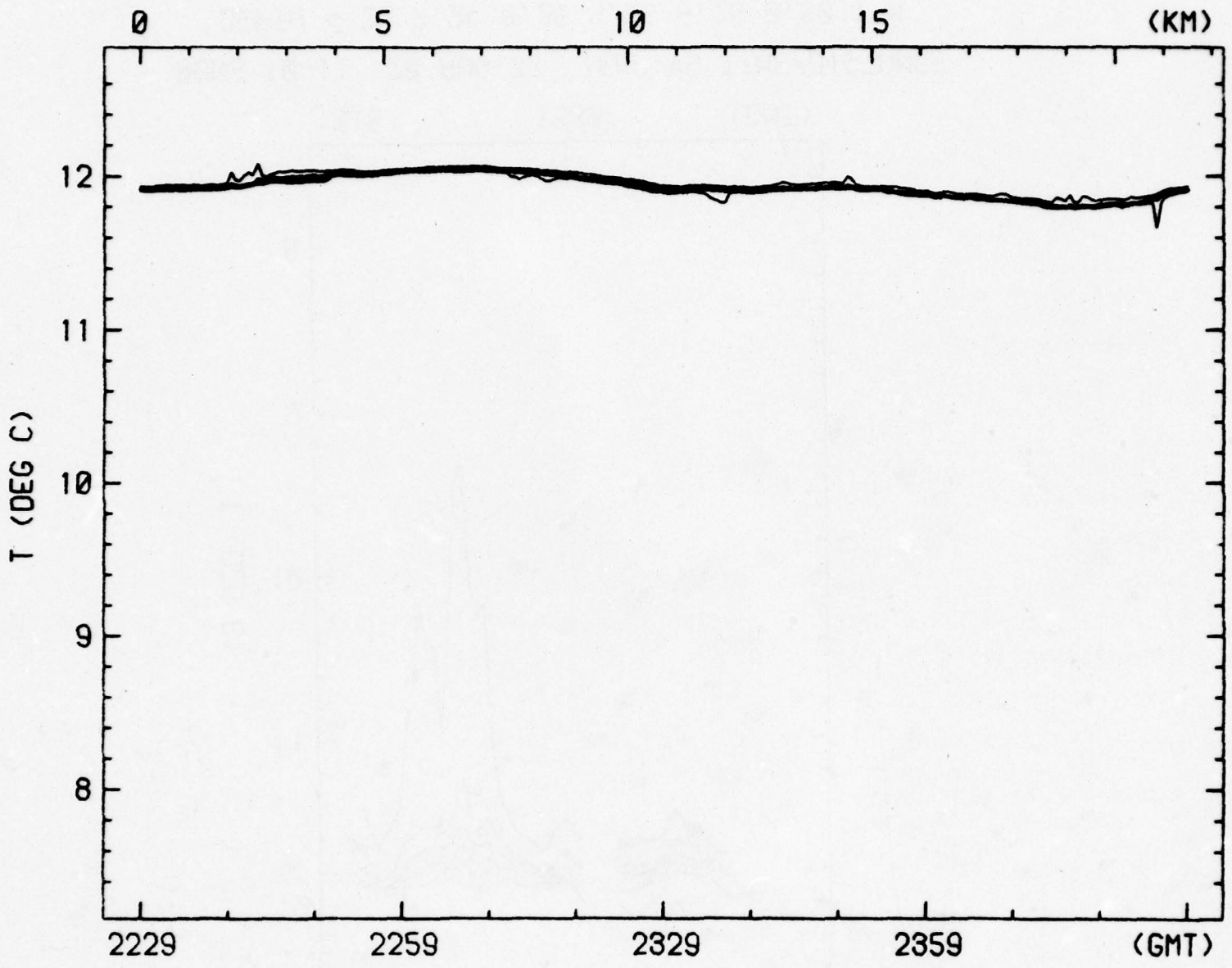

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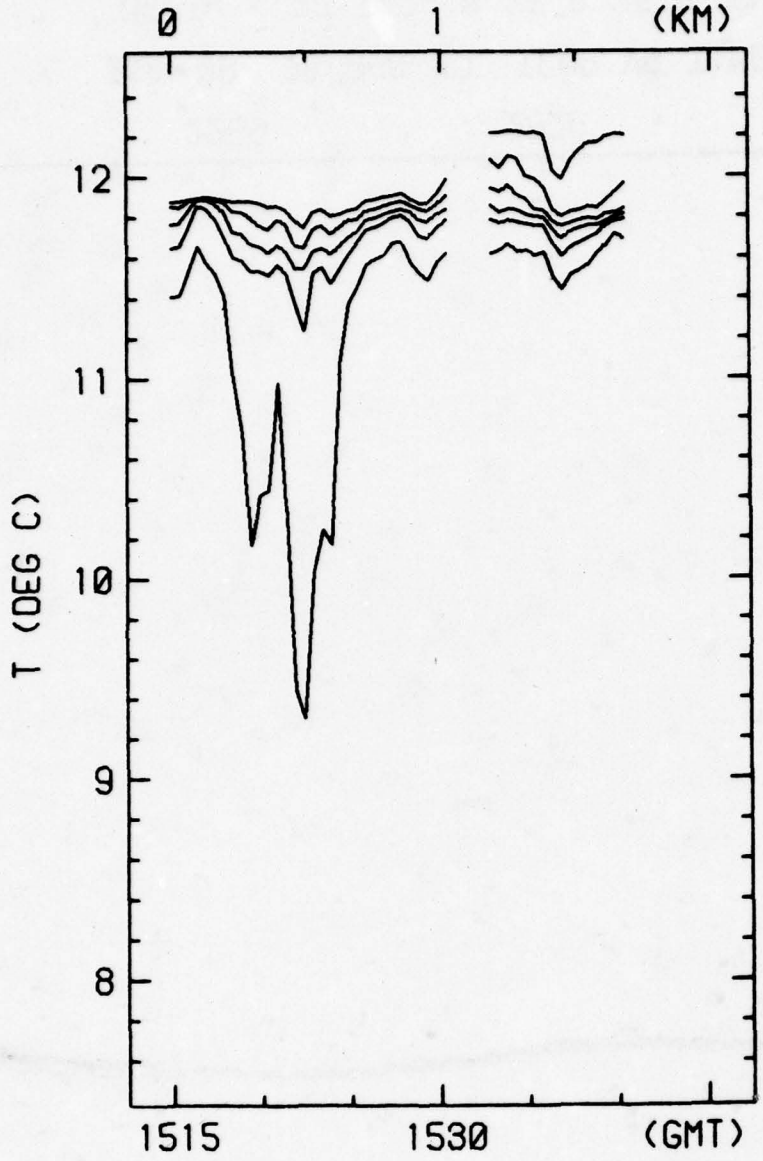

RUNS 10-11 28 AUG 77 TEMP VS TIME/DISTANCE

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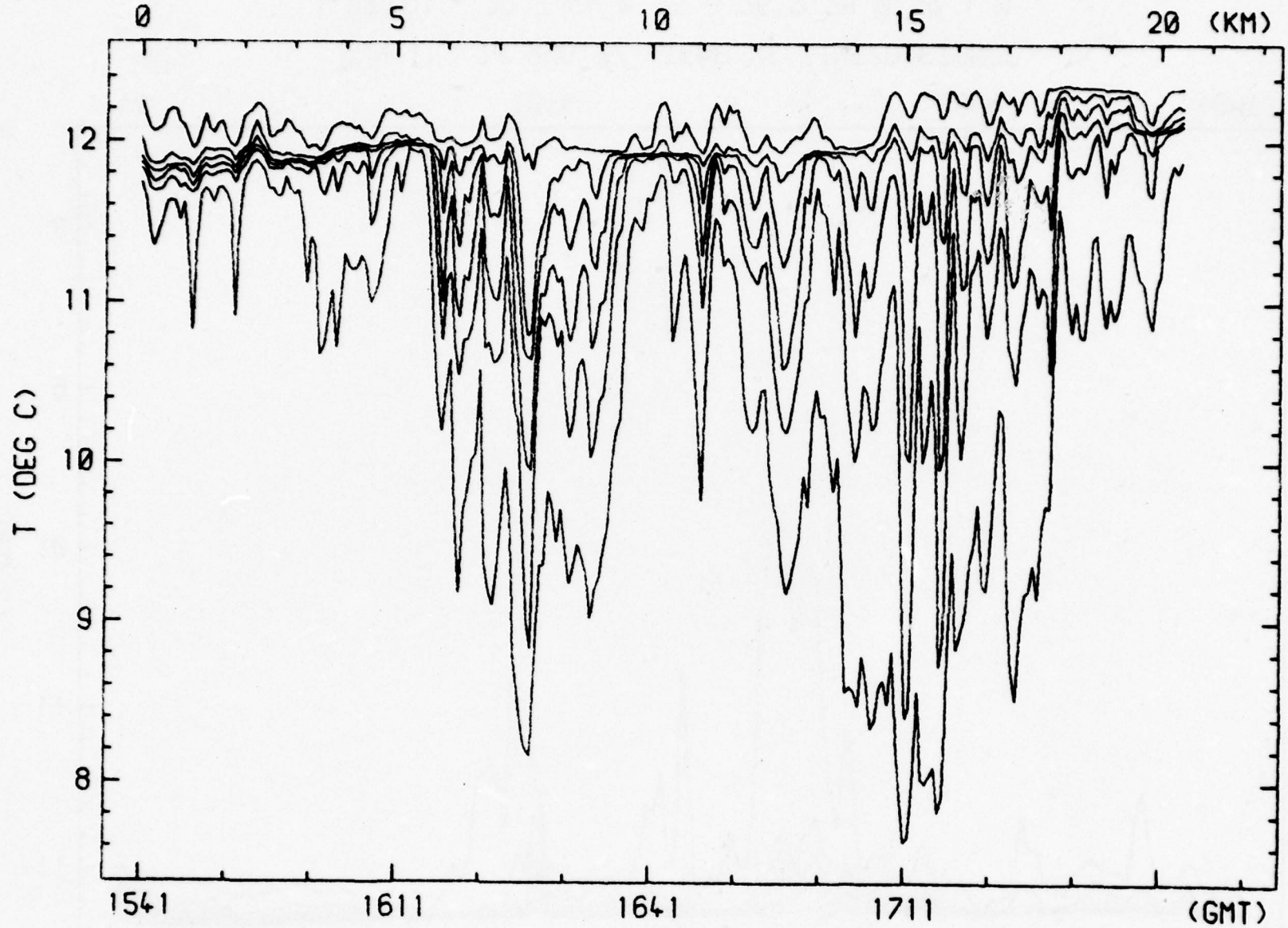

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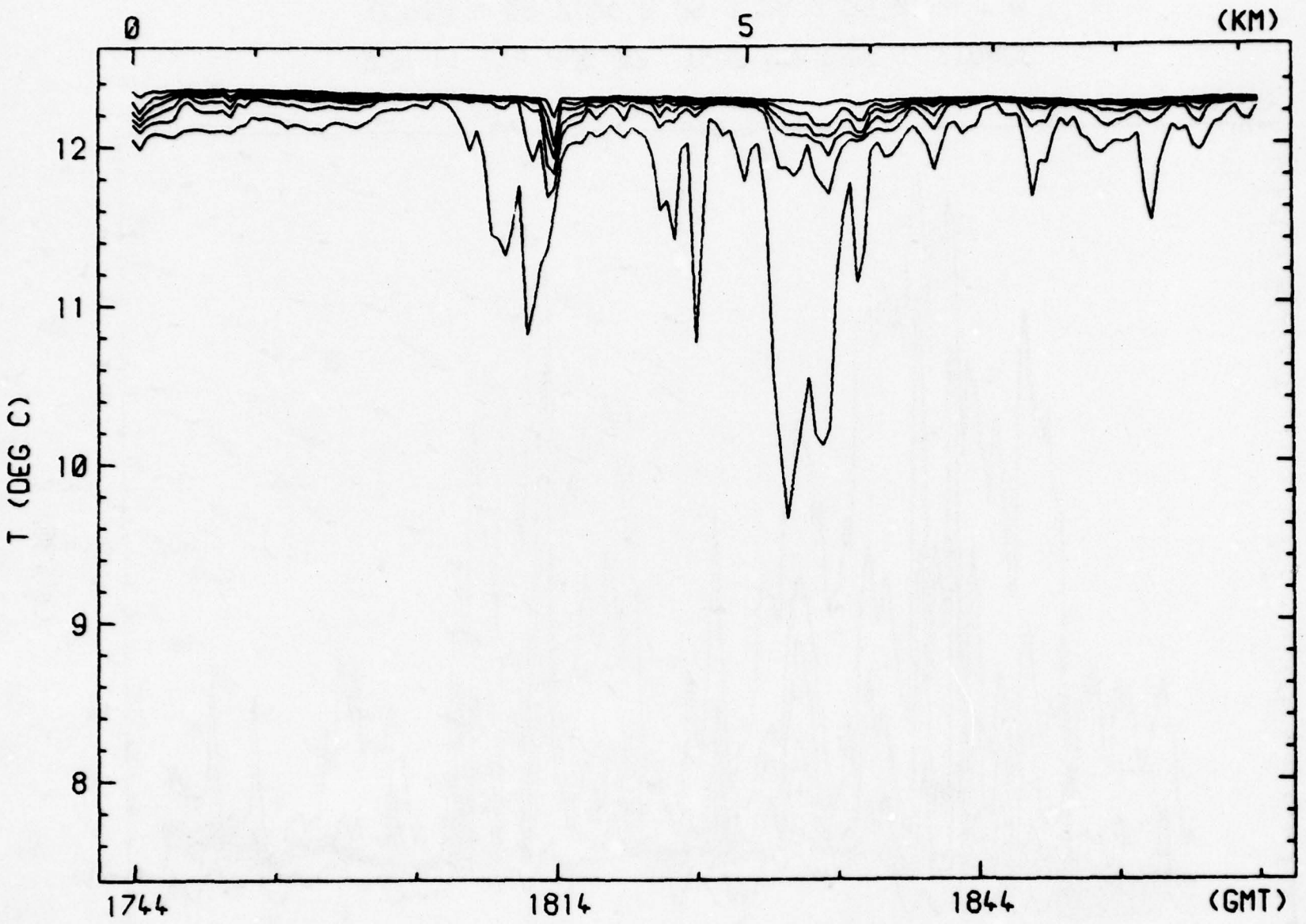

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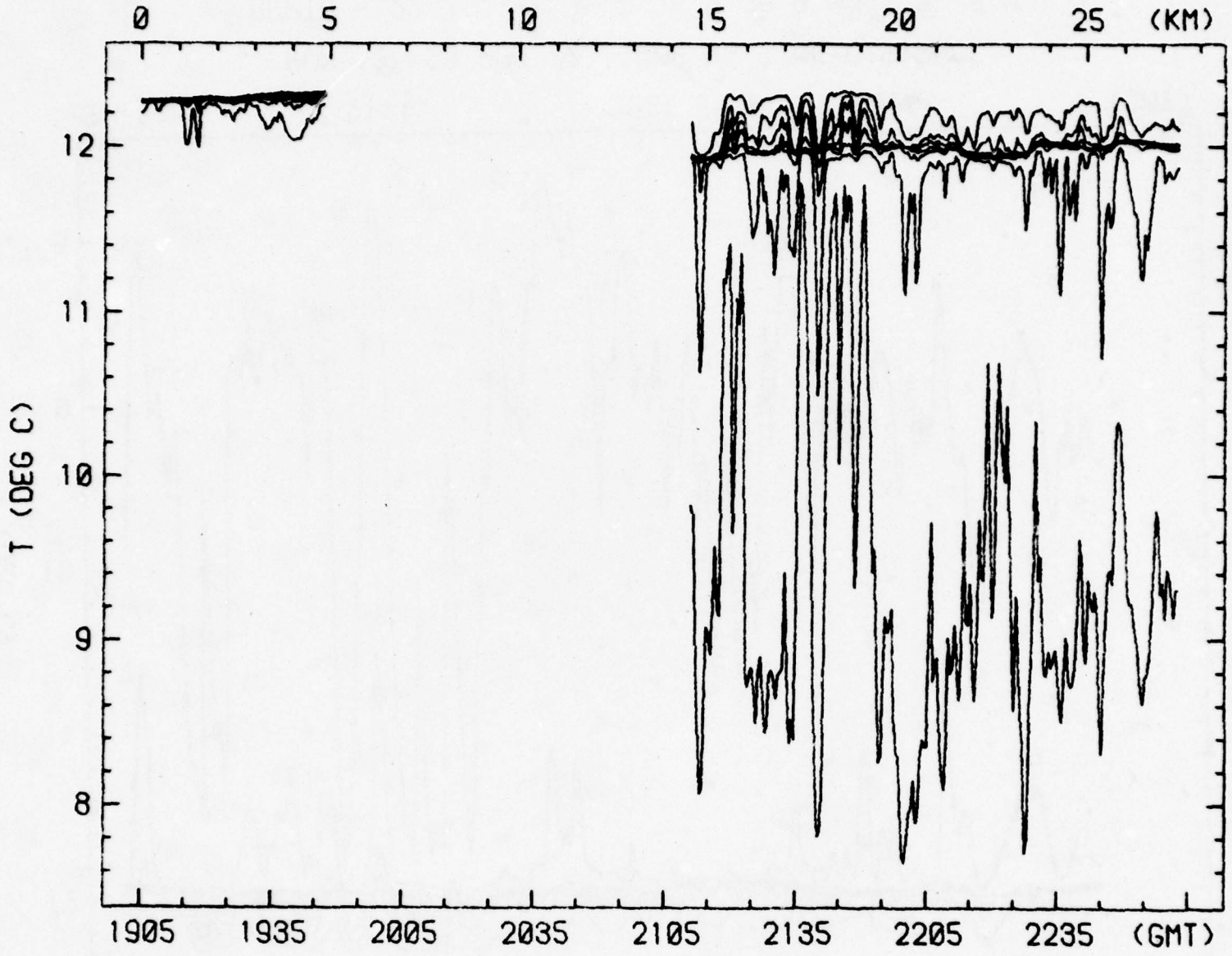

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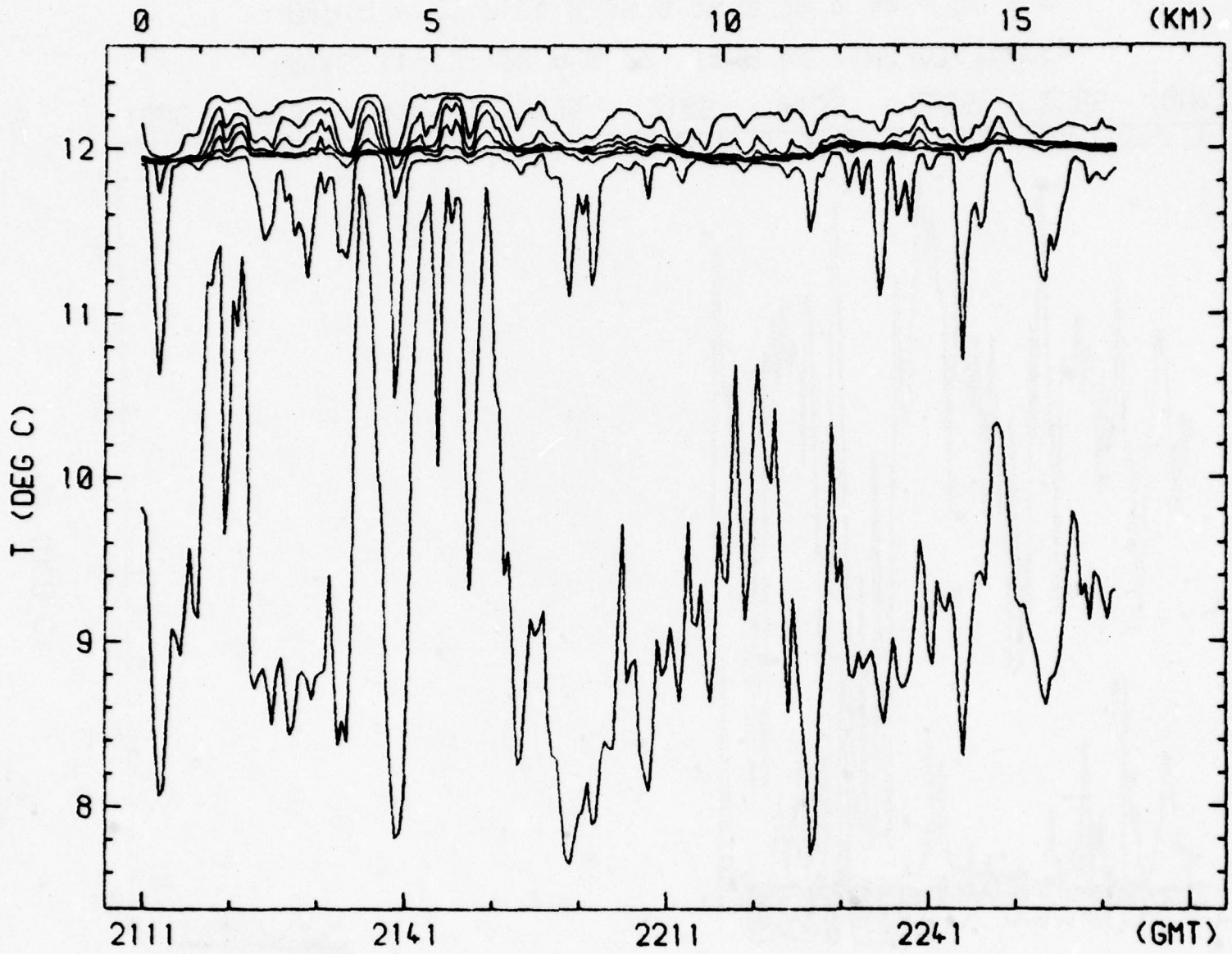

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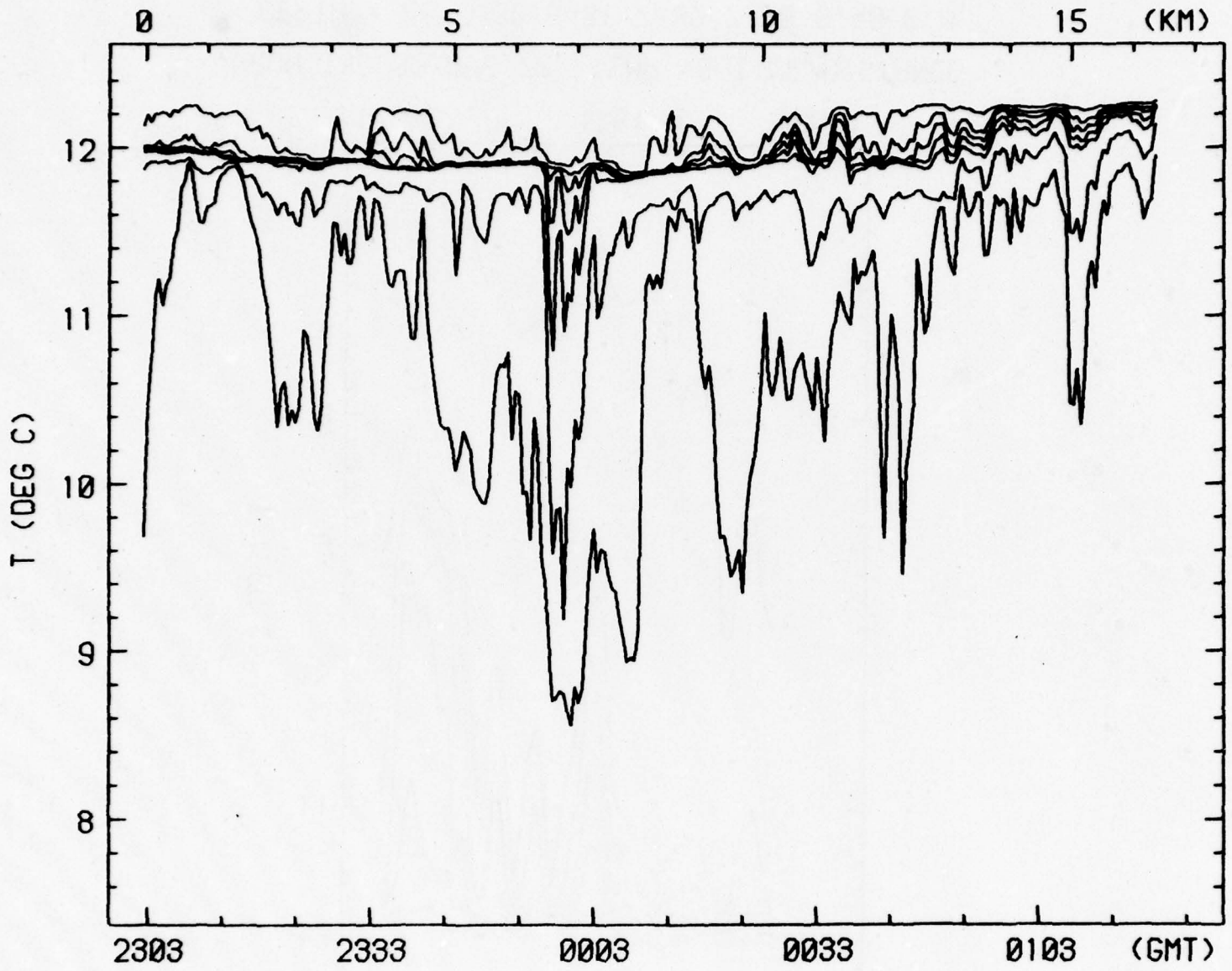

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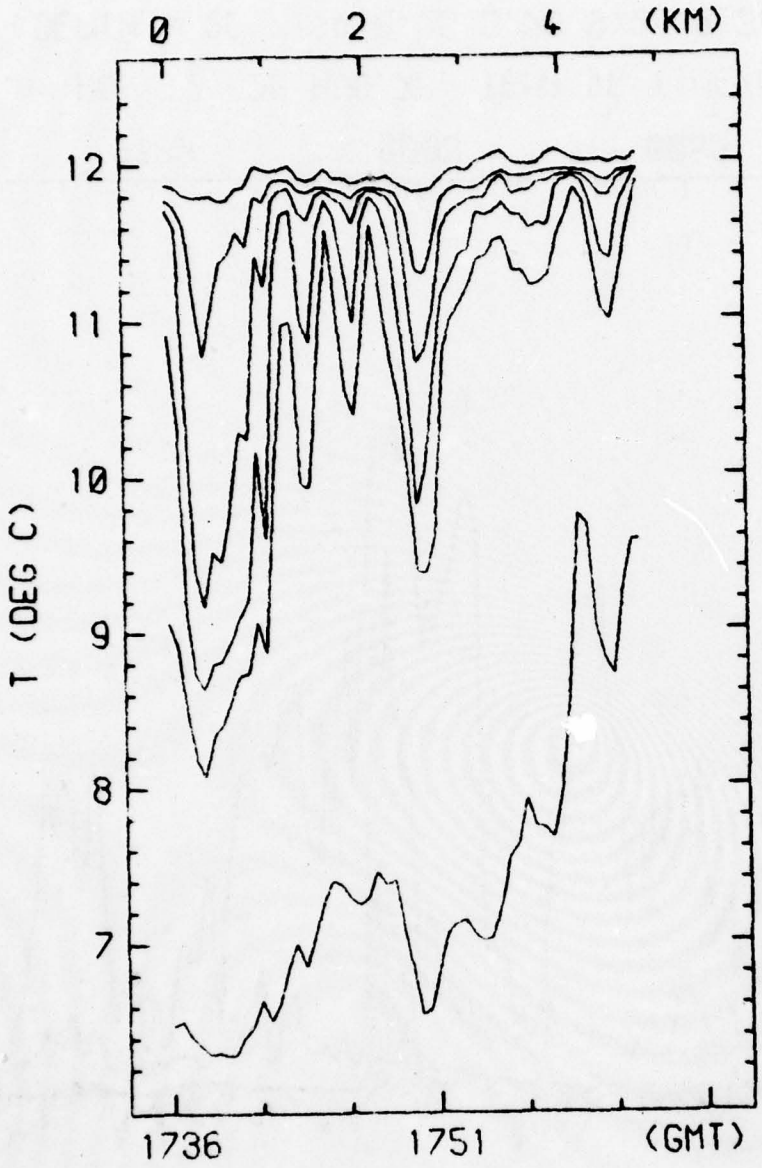

RUN 13 30 AUG 77 TEMP VS TIME/DISTANCE

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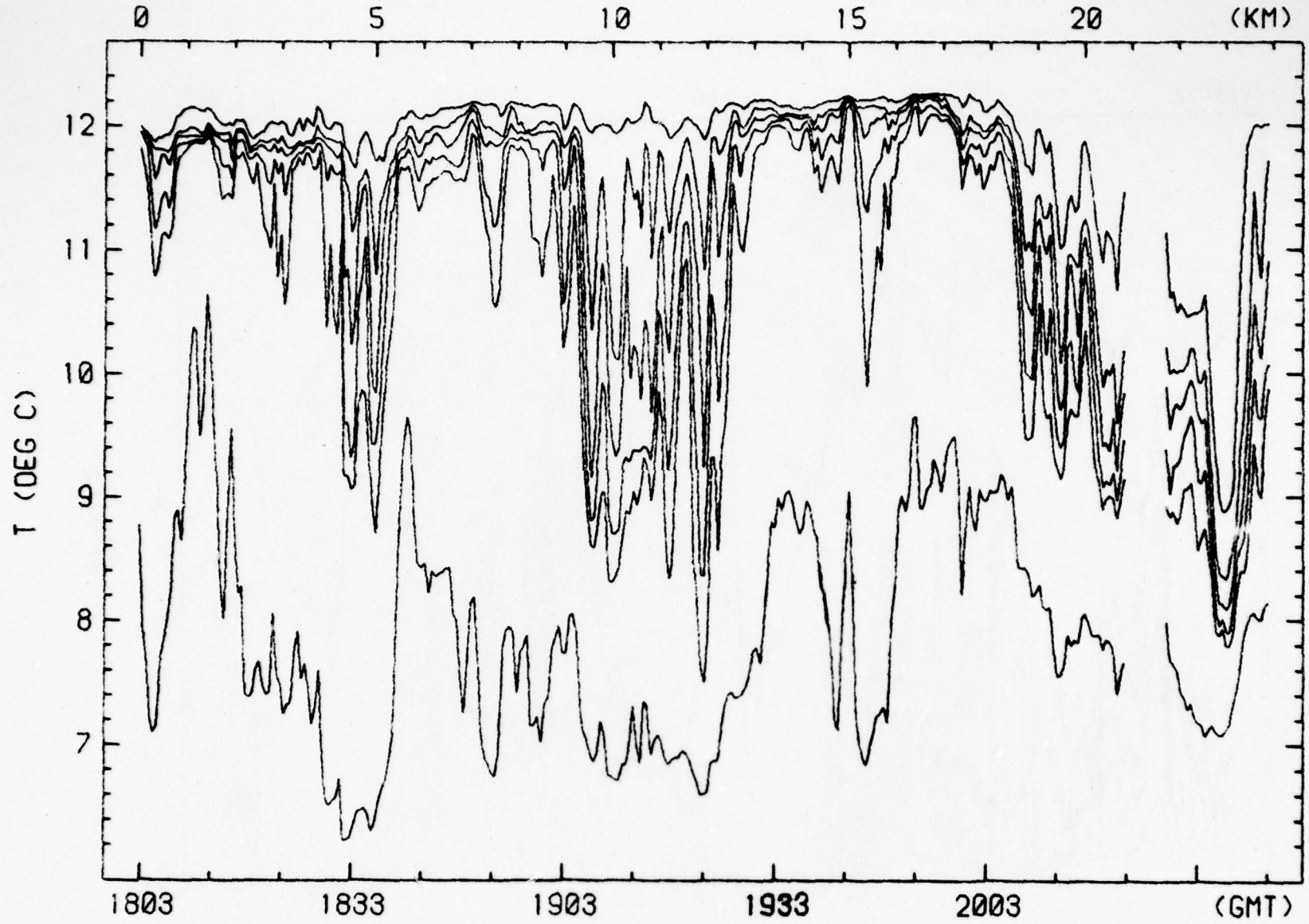

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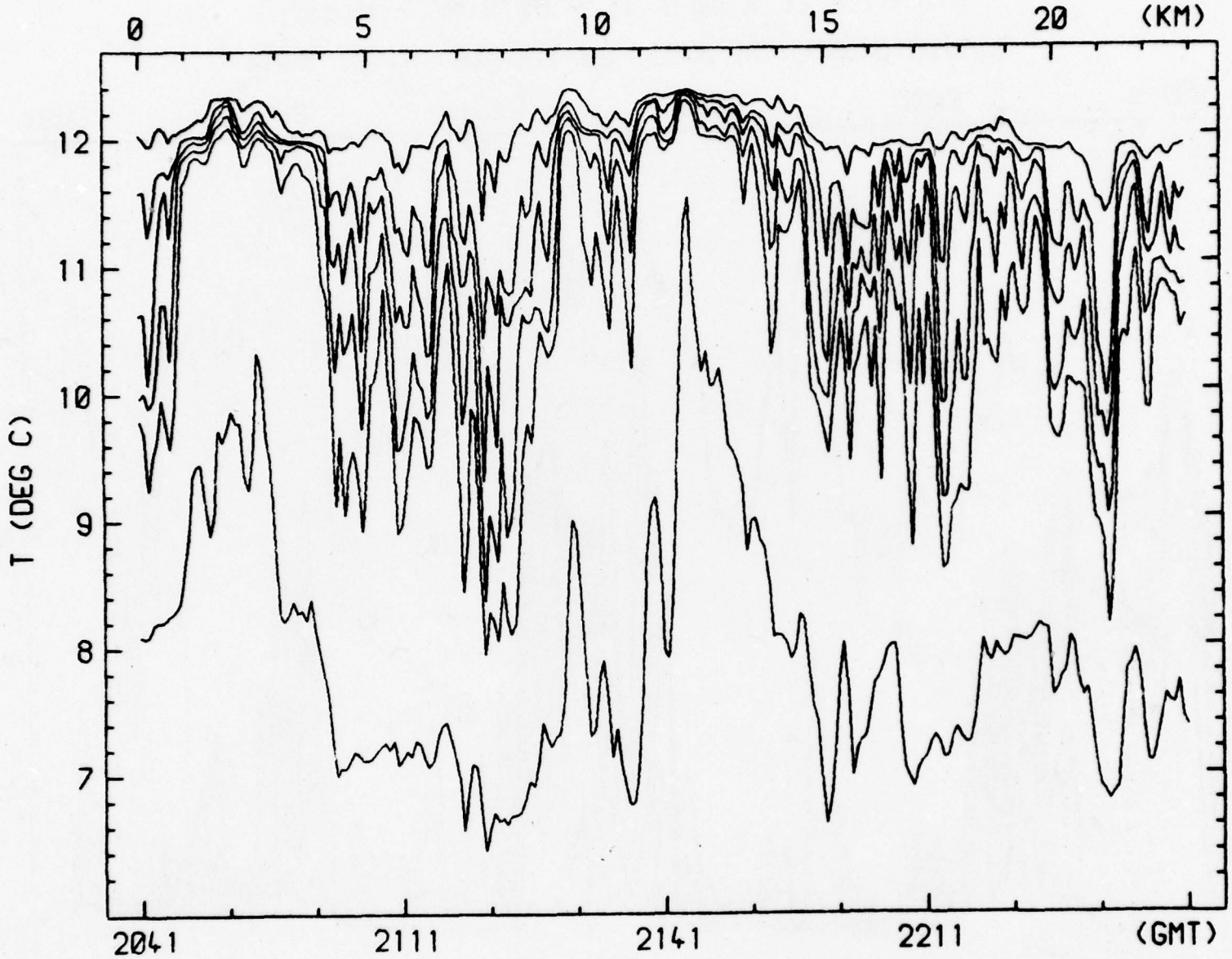
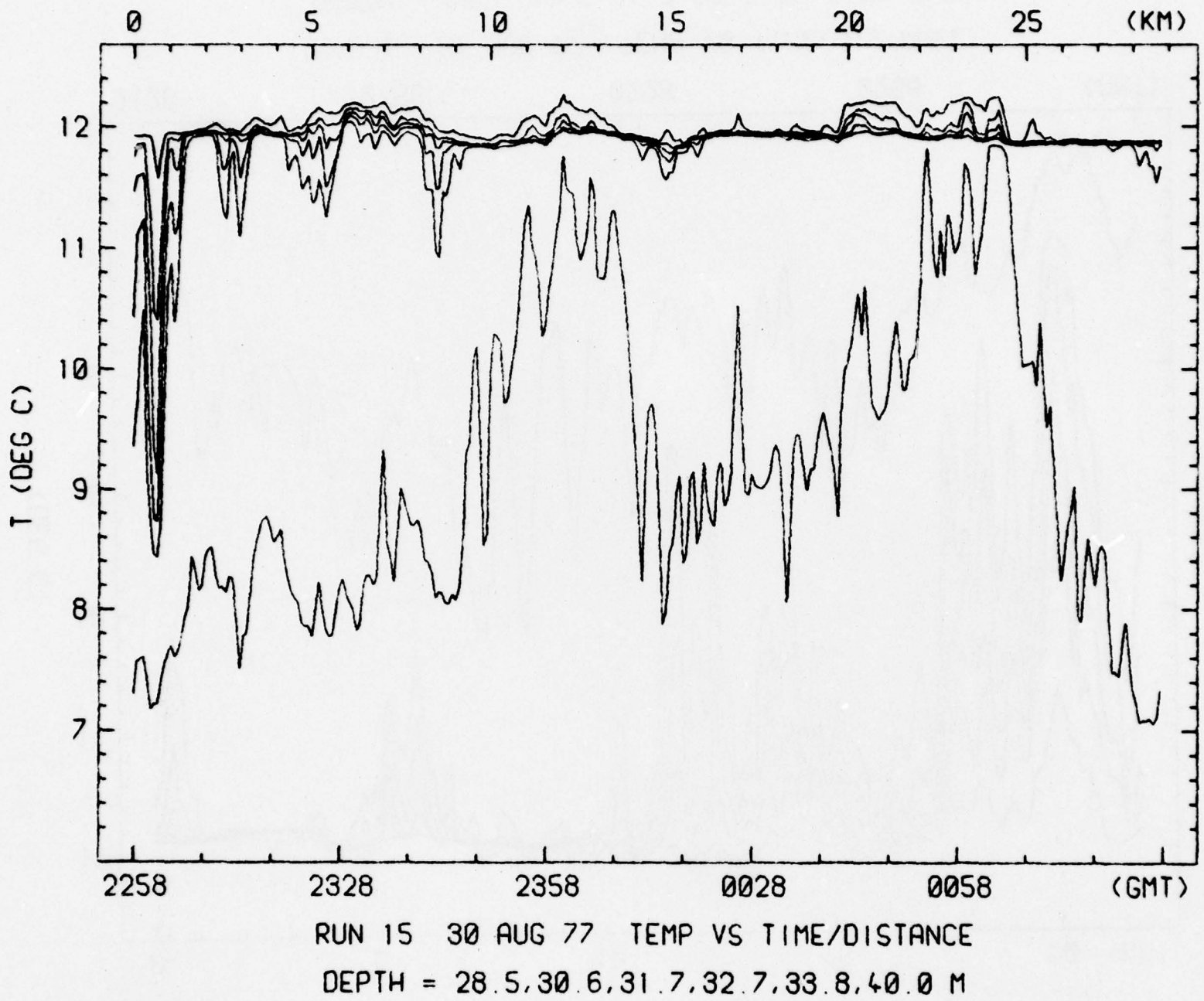
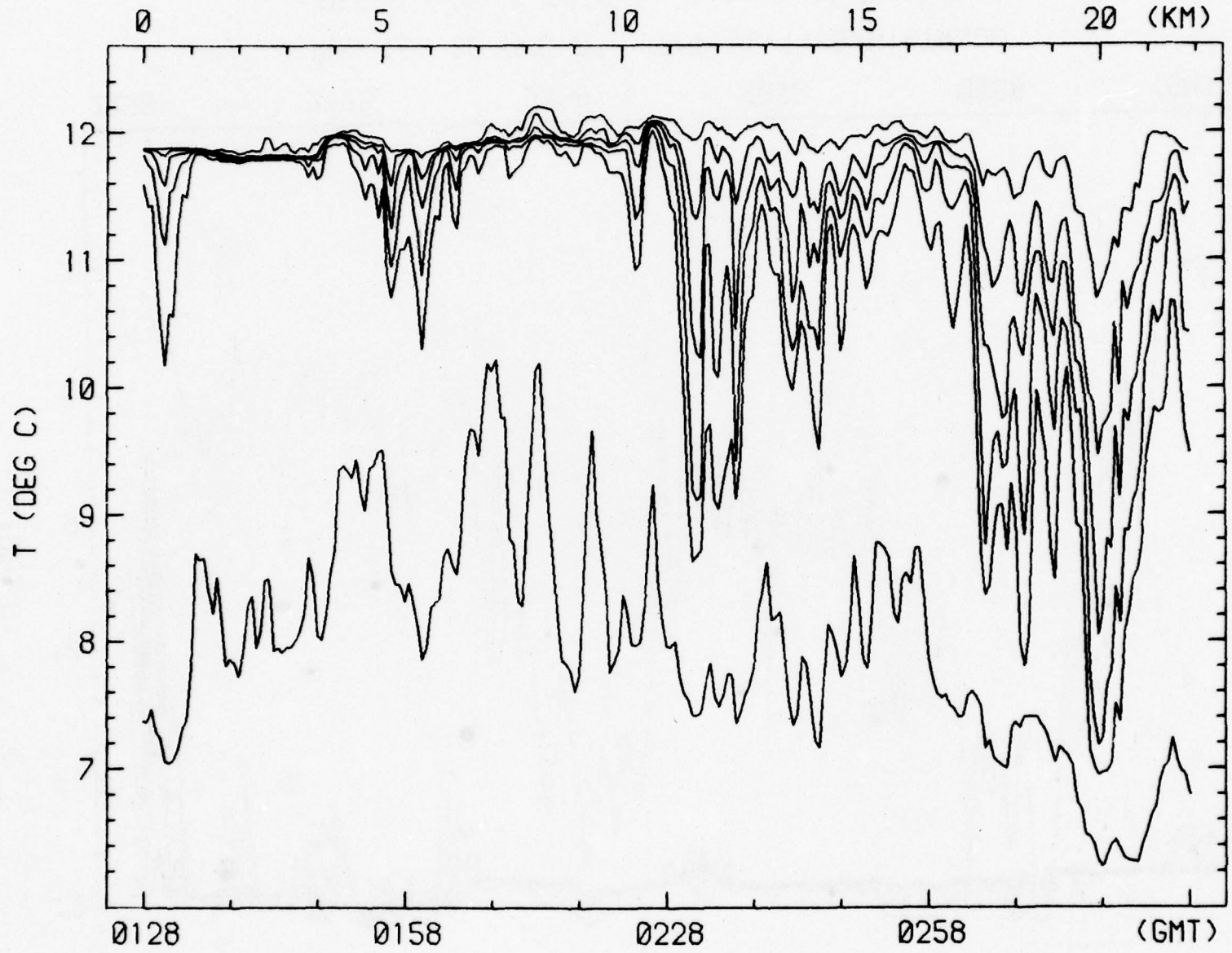


RUN 14 30 AUG 77 TEMP VS TIME/DISTANCE

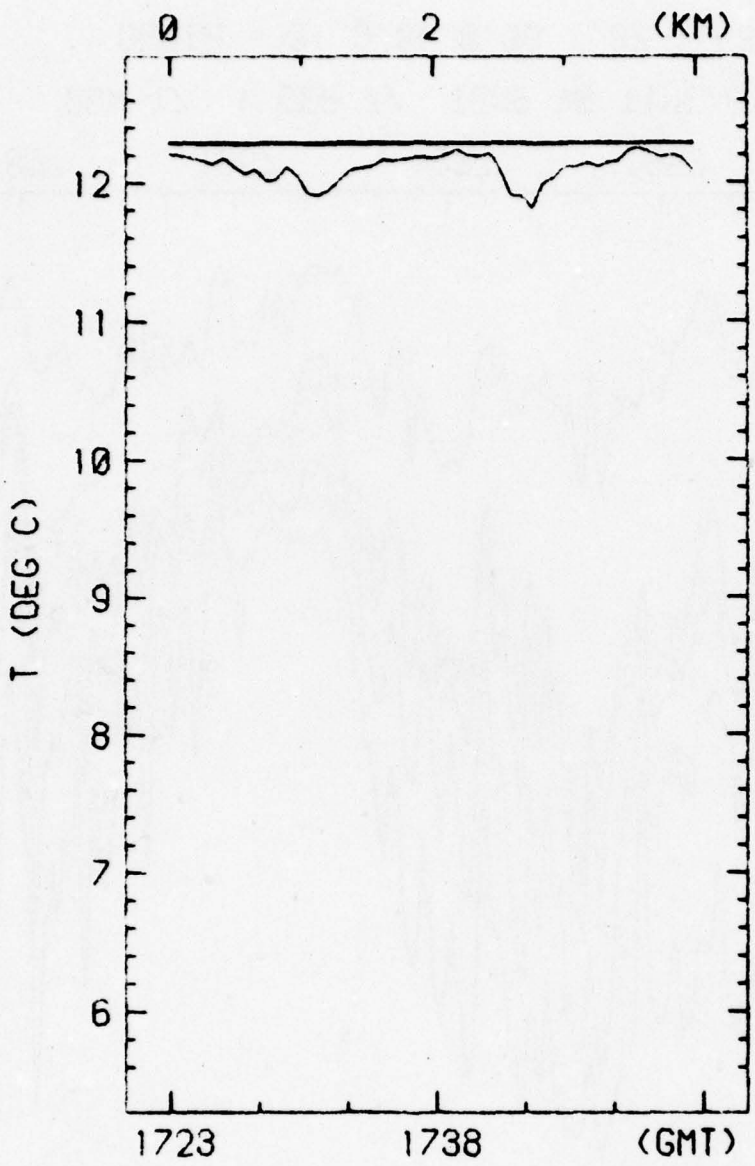
DEPTH = 28.5, 30.6, 31.7, 32.7, 33.8, 40.0 M


0
5
10
15
20
25
(KM)
12
11
10
9
8
7
T (DEG C)
2258
2328
2358
0028
0058
(GMT)
RUN 15 30 AUG 77 TEMP VS TIME/DISTANCE
DEPTH = 28.5,30.6,31.7,32.7,33.8,40.0 M



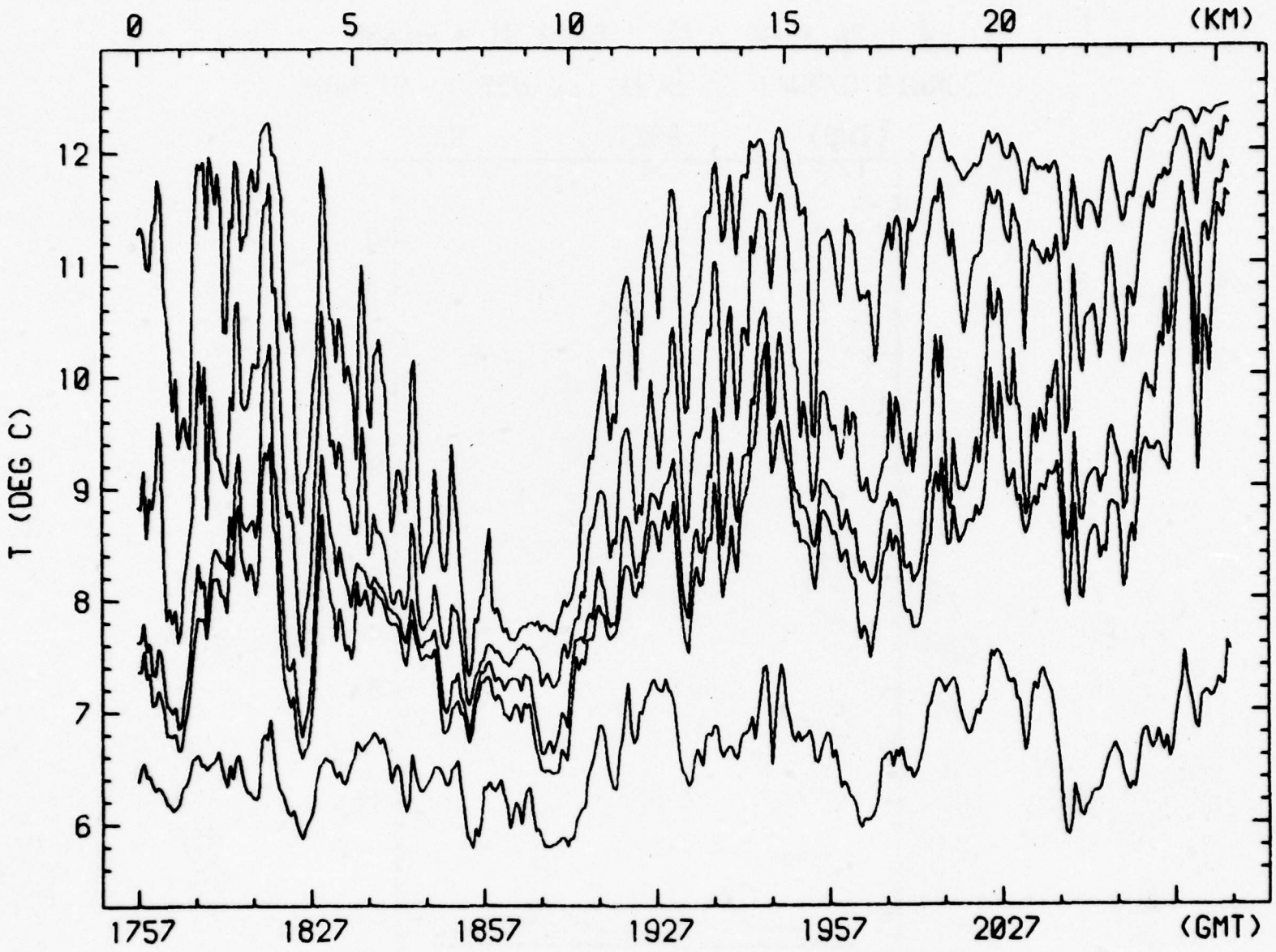
RUN 15 31 AUG 77 TEMP VS TIME/DISTANCE

DEPTH = 28.5,30.6,31.7,32.7,33.8,40.0 M



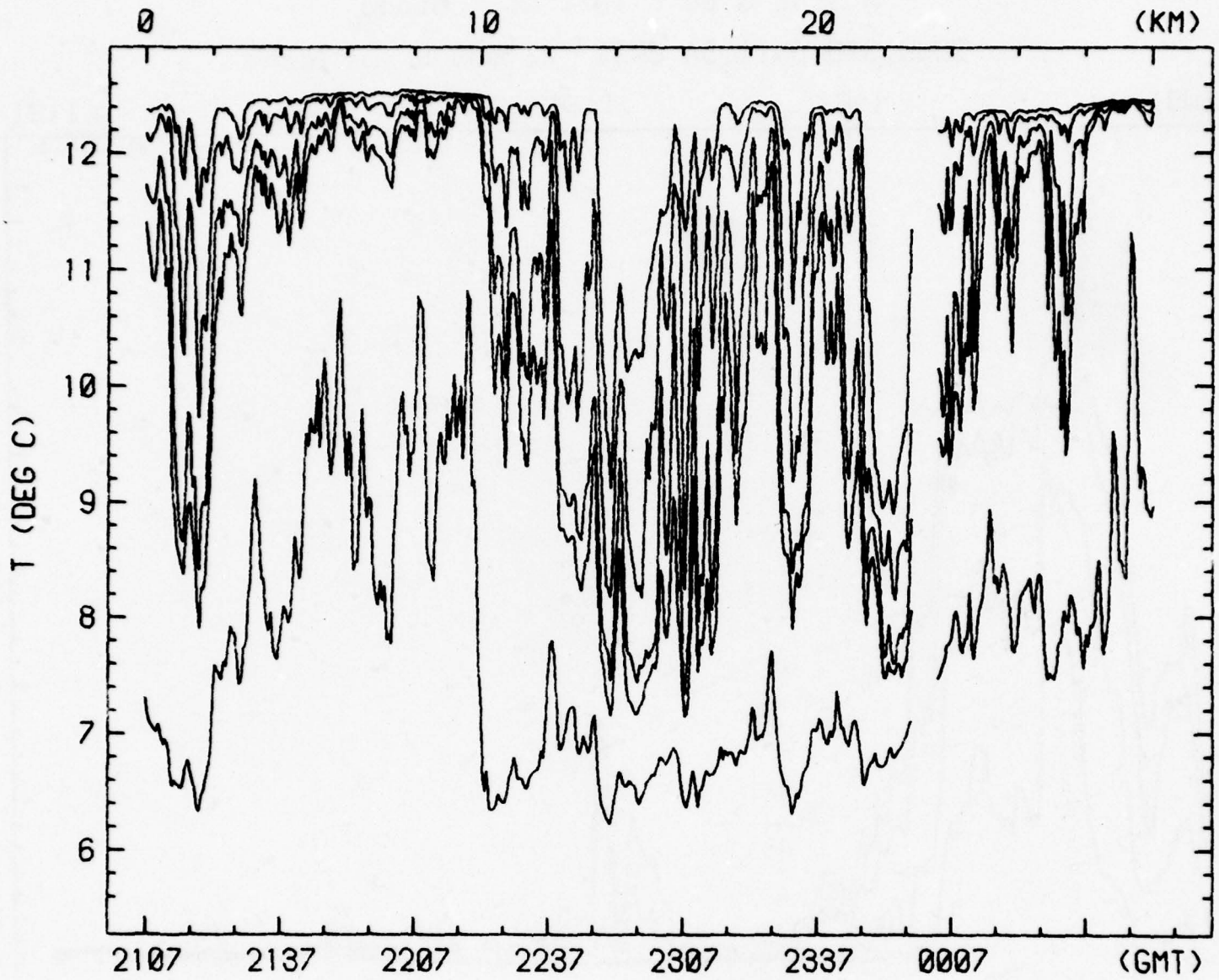
RUN 16 1 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 18.6, 20.7, 22.7, 23.8, 30.1 M



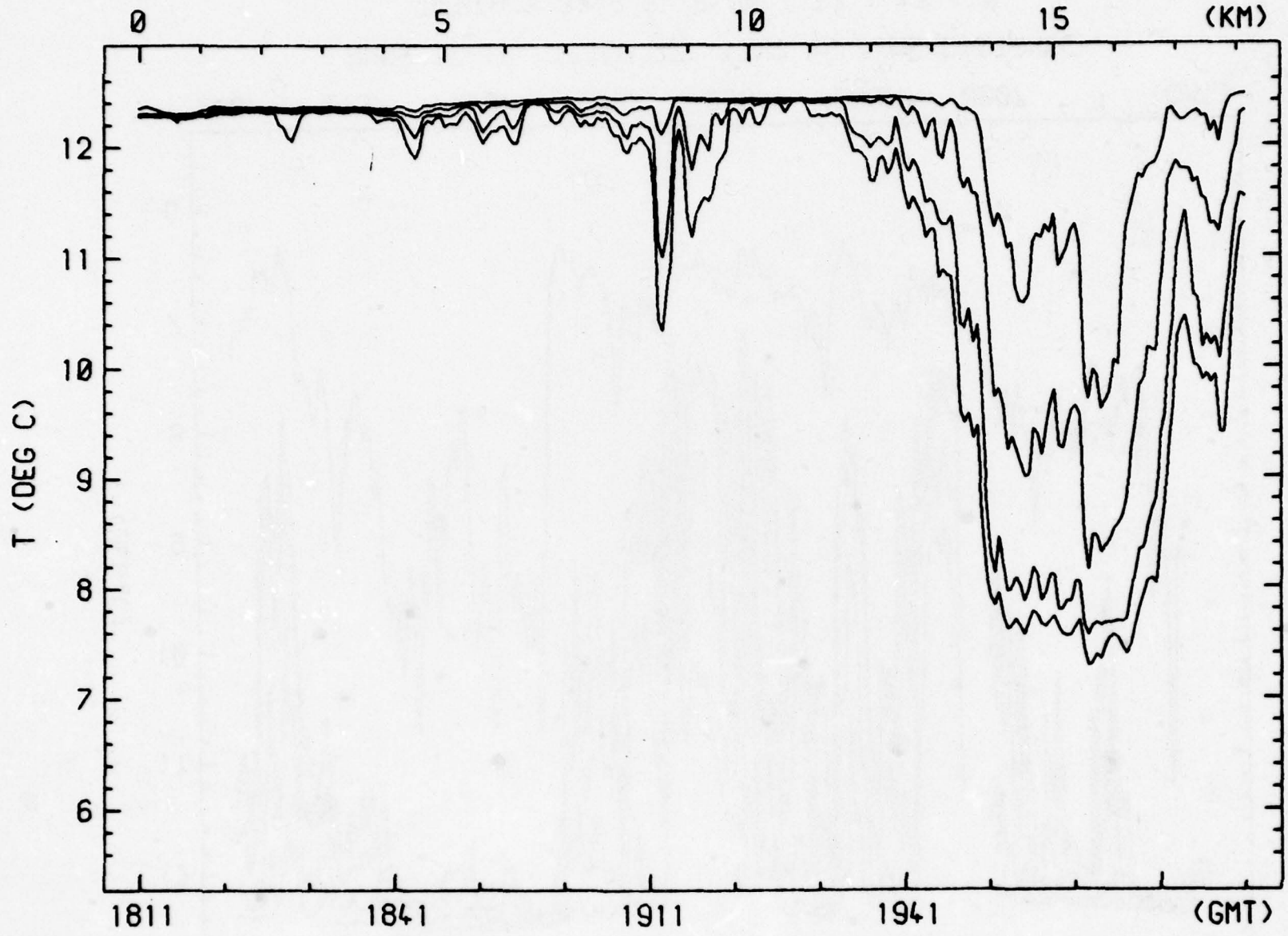
RUN 17 1 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 31.9, 34.0, 36.1, 37.1, 43.4 M



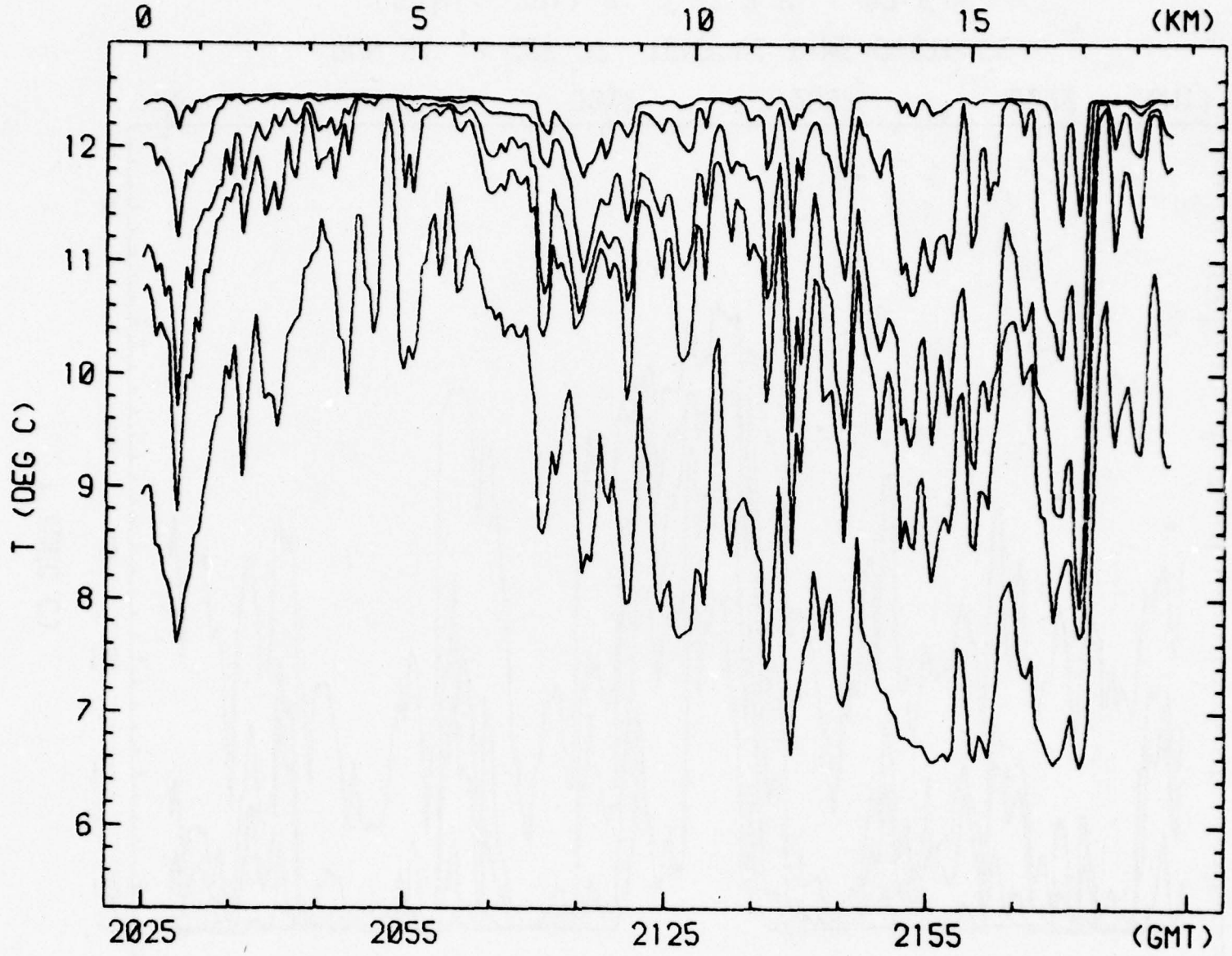
RUNS 17-18 1 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 31.9,34.0,36.1,37.1,43.4 M



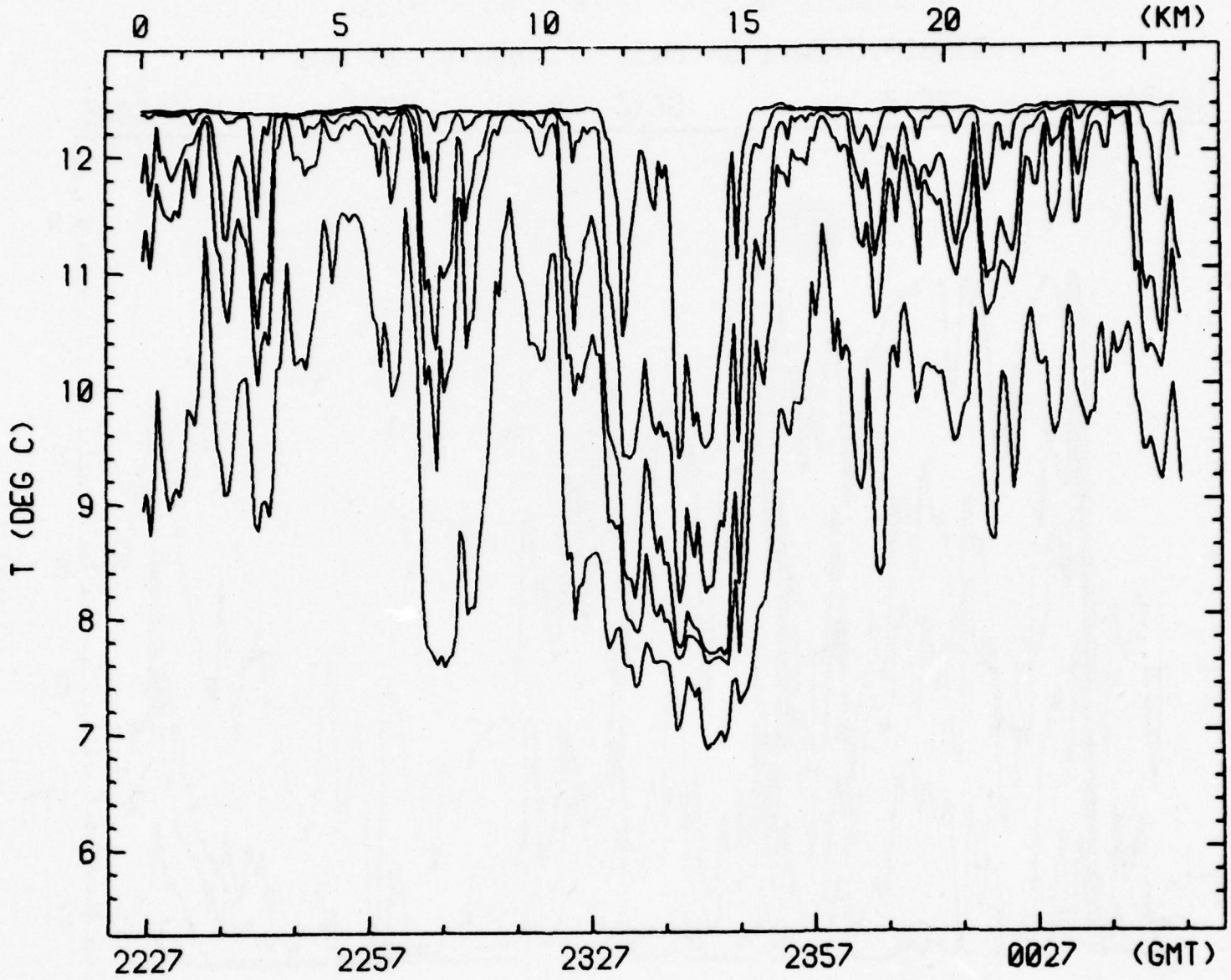
RUN 19 3 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 29.1, 31.2, 33.3, 34.4 M



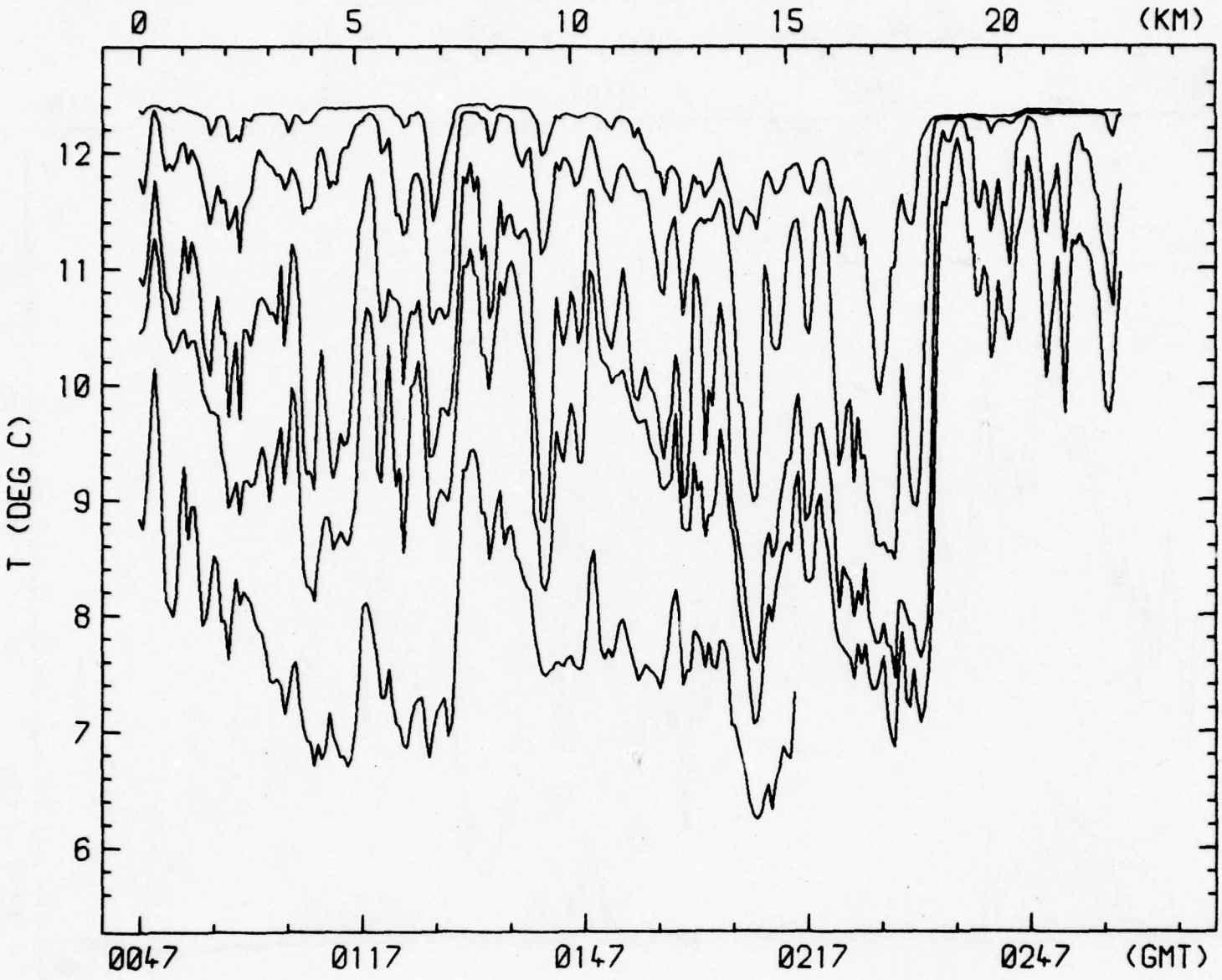
RUN 20 3 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 29.1, 31.2, 33.3, 34.4, 37.5 M



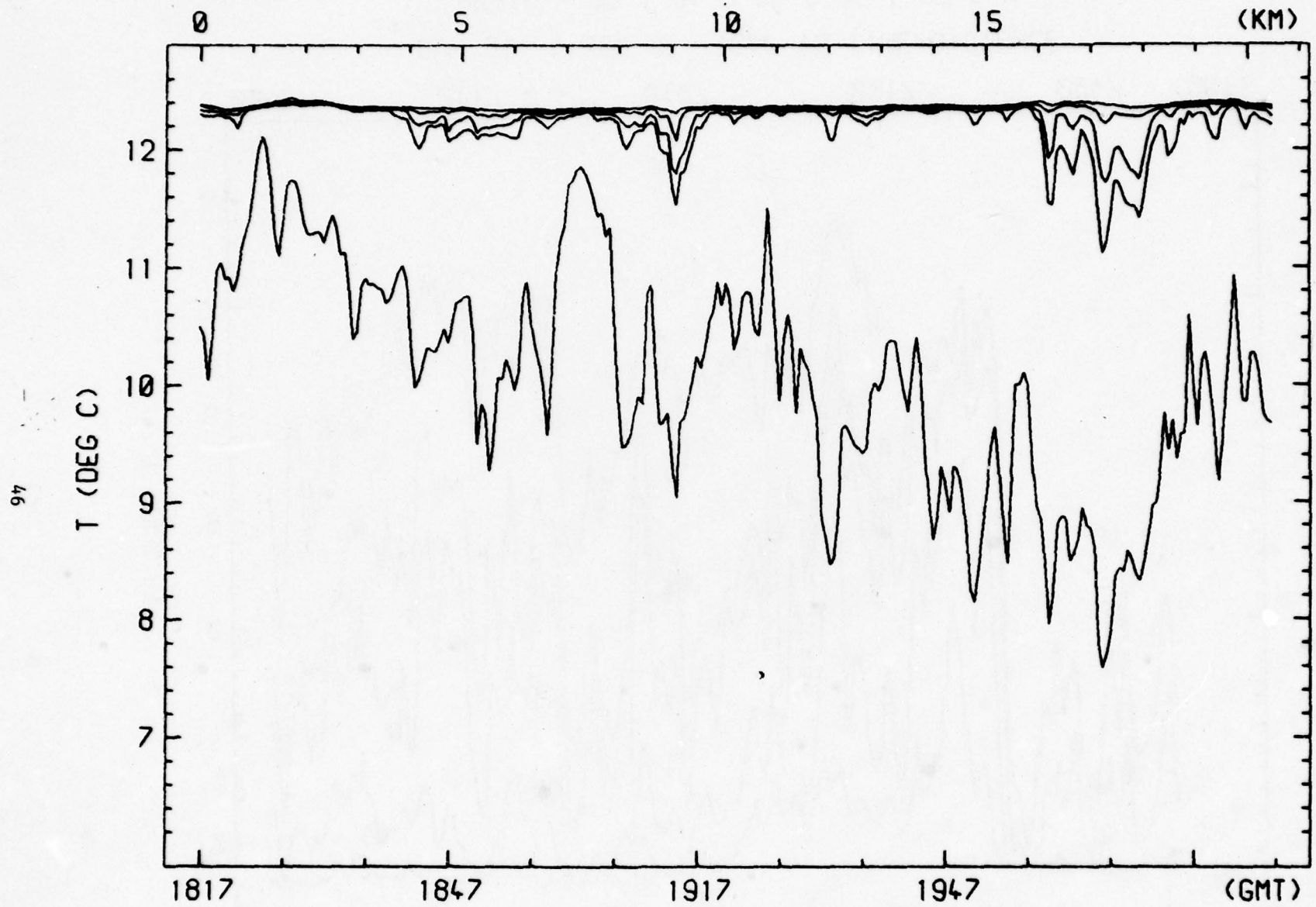
RUN 21 3 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 29.1, 31.2, 33.3, 34.4, 37.5 M



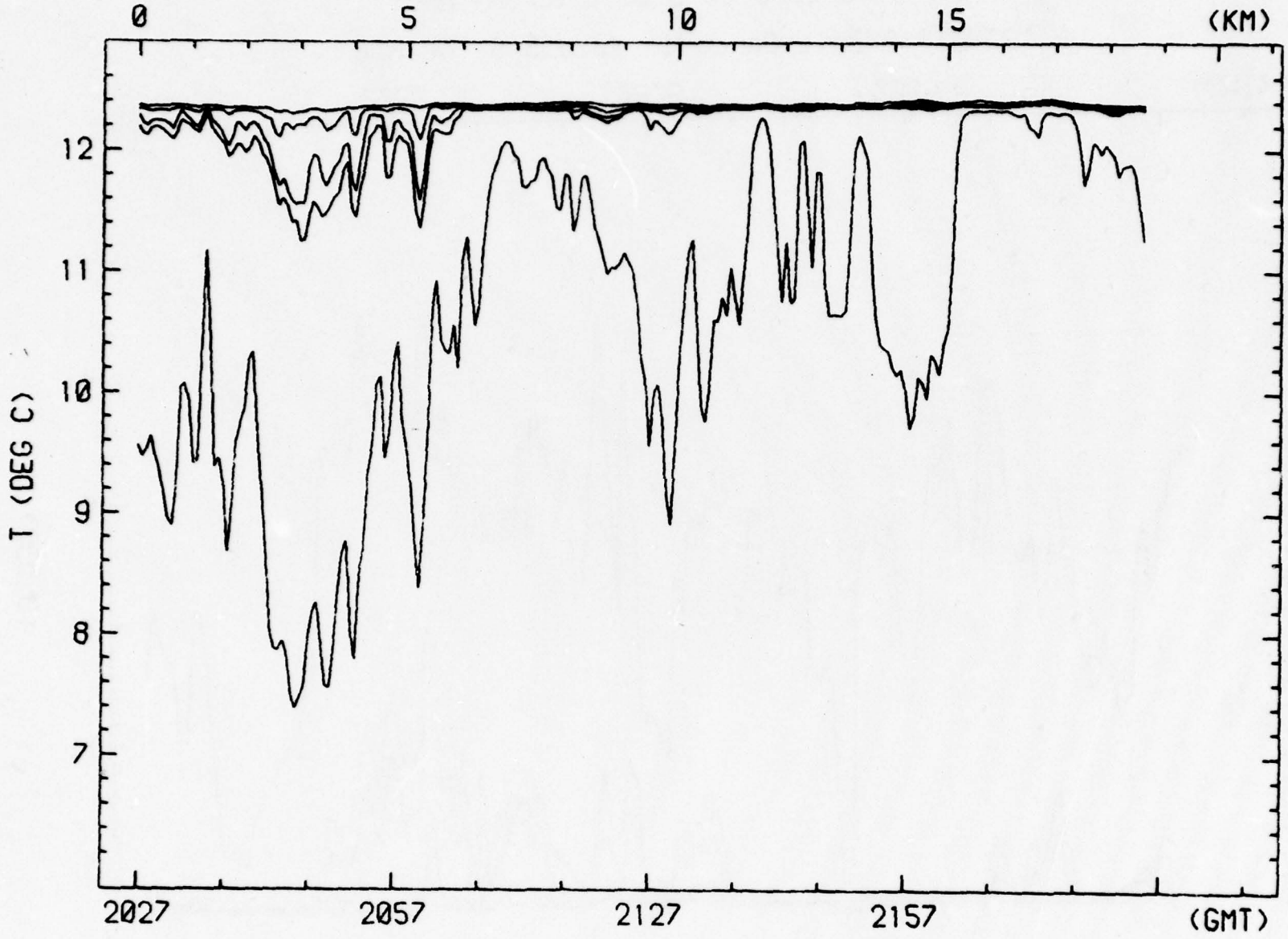
RUN 21 4 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 29.1, 31.2, 33.3, 34.4, 37.5 M



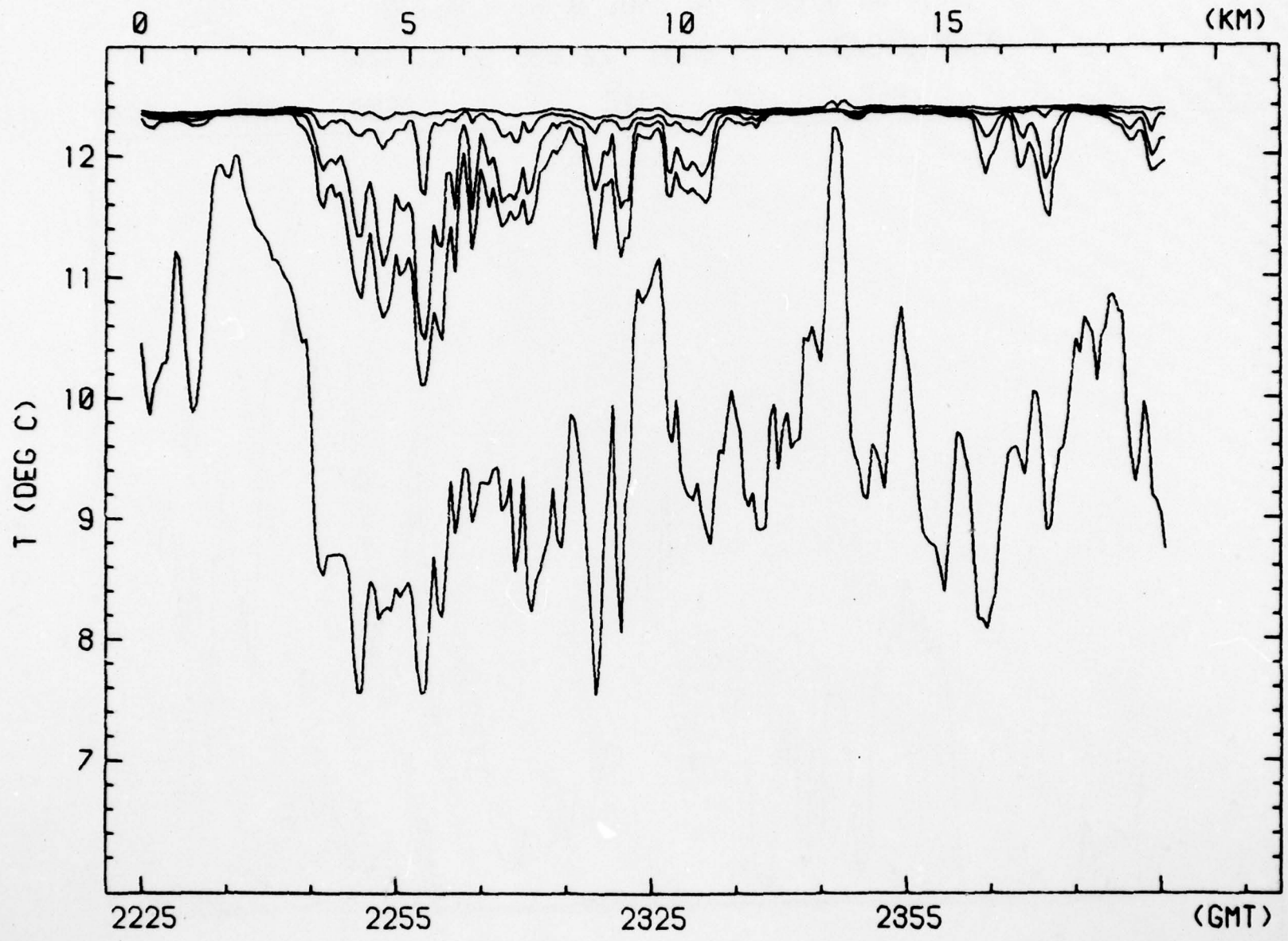
RUN 22 5 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 28.6, 30.7, 32.8, 33.8, 40.1 M



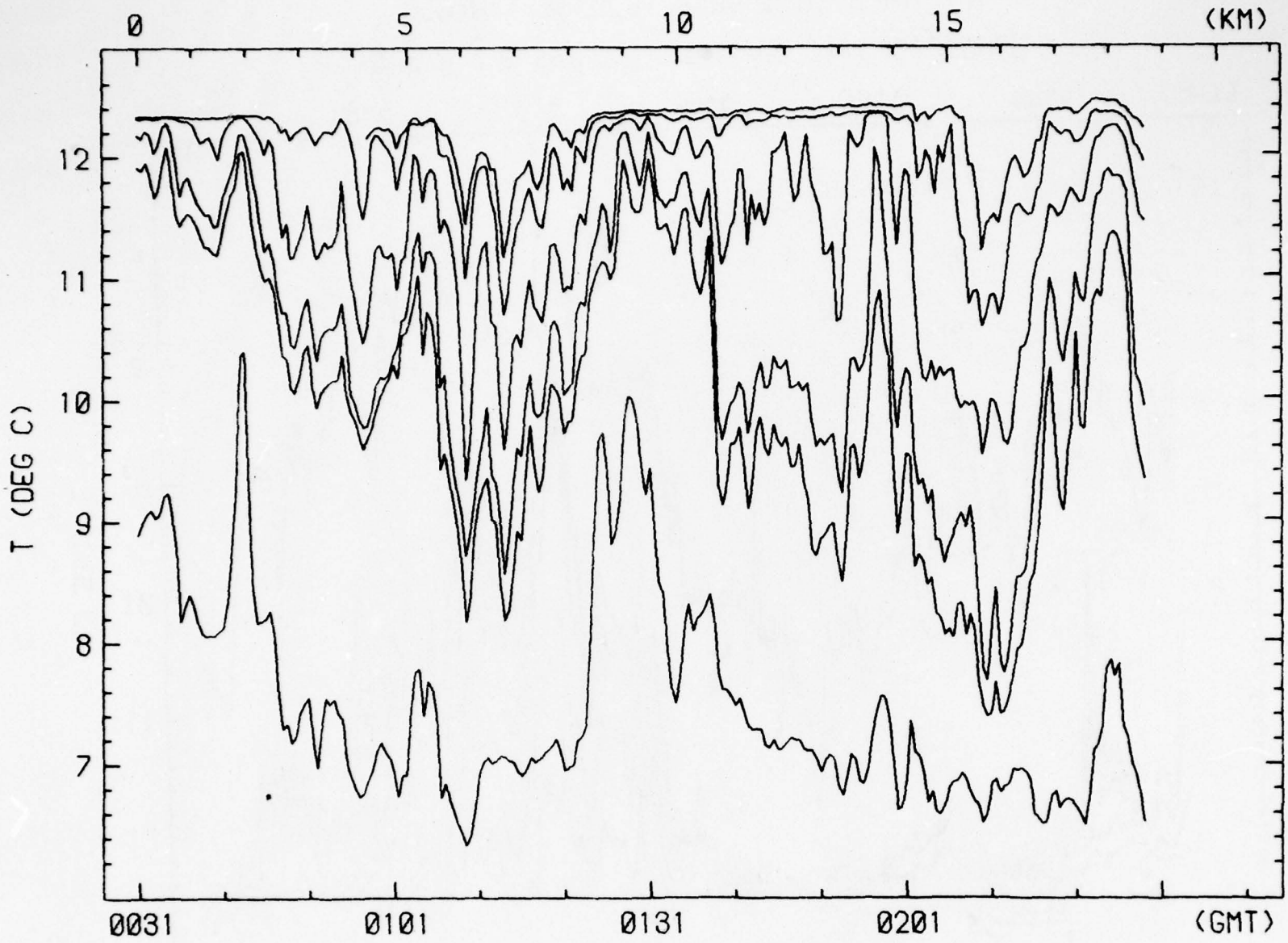
RUN 22 5 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 28.6,30.7,32.8,33.8,40.1 M



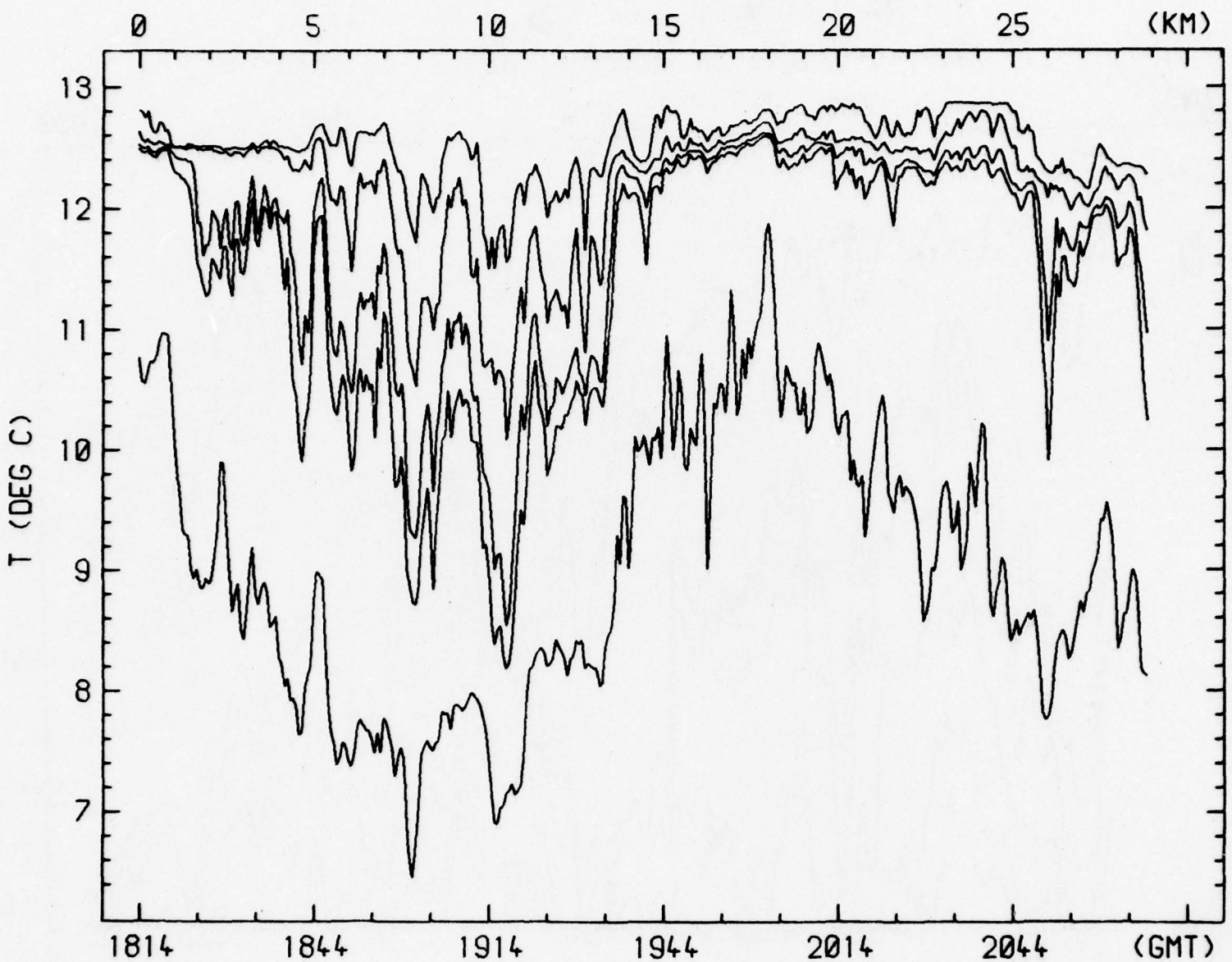
RUN 22 5 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 28.6, 30.7, 32.8, 33.8, 40.1 M



RUN 23 6 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 27.5,28.6,30.7,32.8,33.8,40.1 M



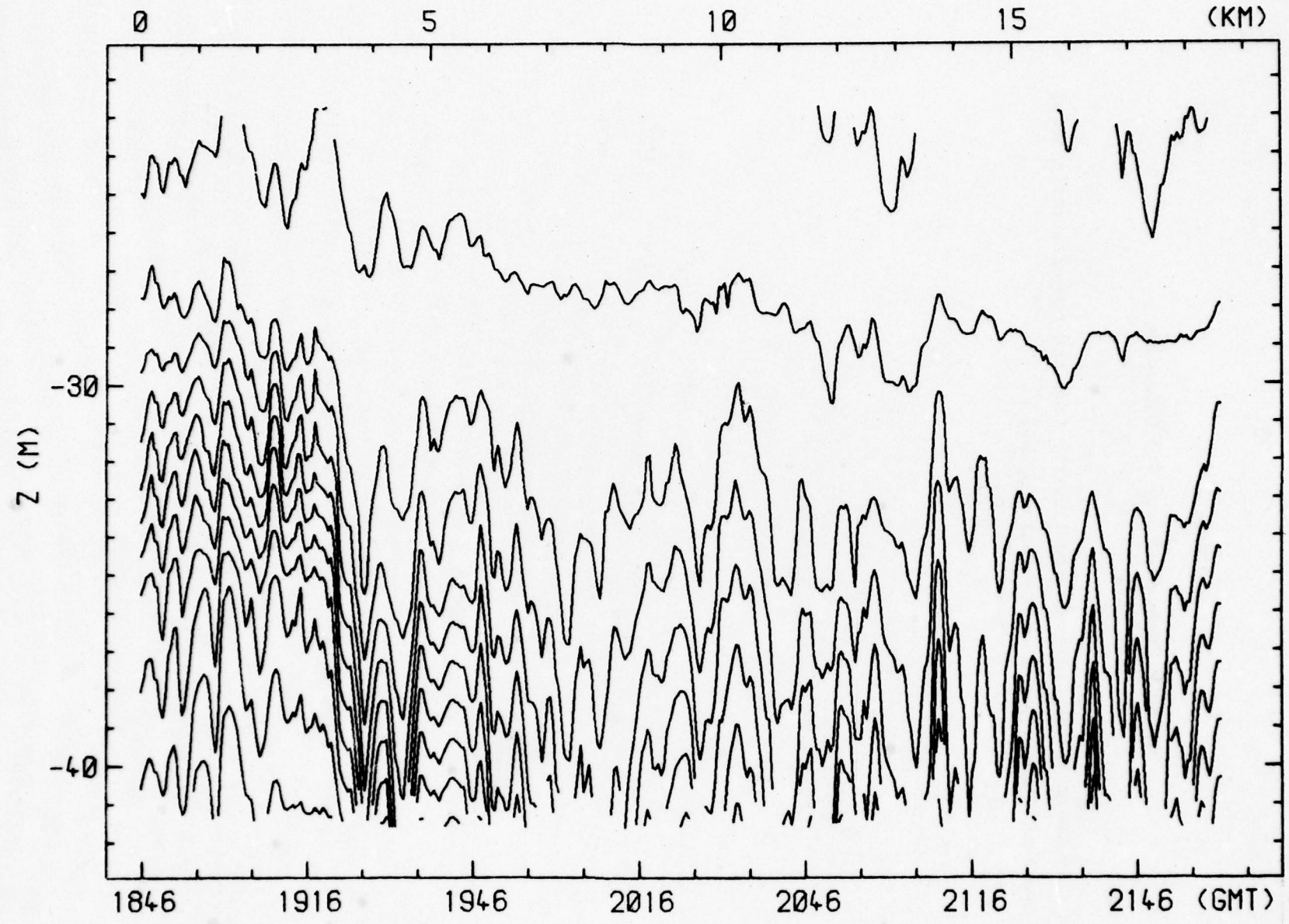
RUN 24 8 SEP 77 TEMP VS TIME/DISTANCE

DEPTH = 29.7, 31.8, 33.9, 34.9, 41.2 M

APPENDIX C

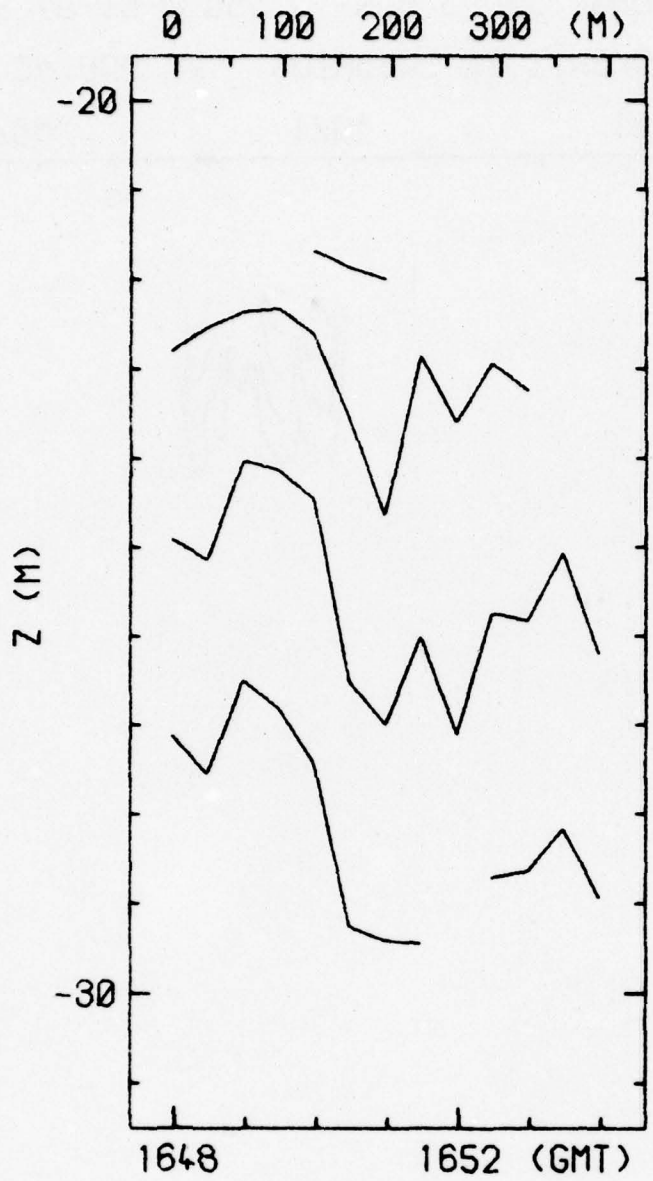
Isotherm Cross-sections, 0.5°C Spacing

Isotherm depths, interpolated linearly from the temperatures plotted in Appendix B are plotted on the following pages.



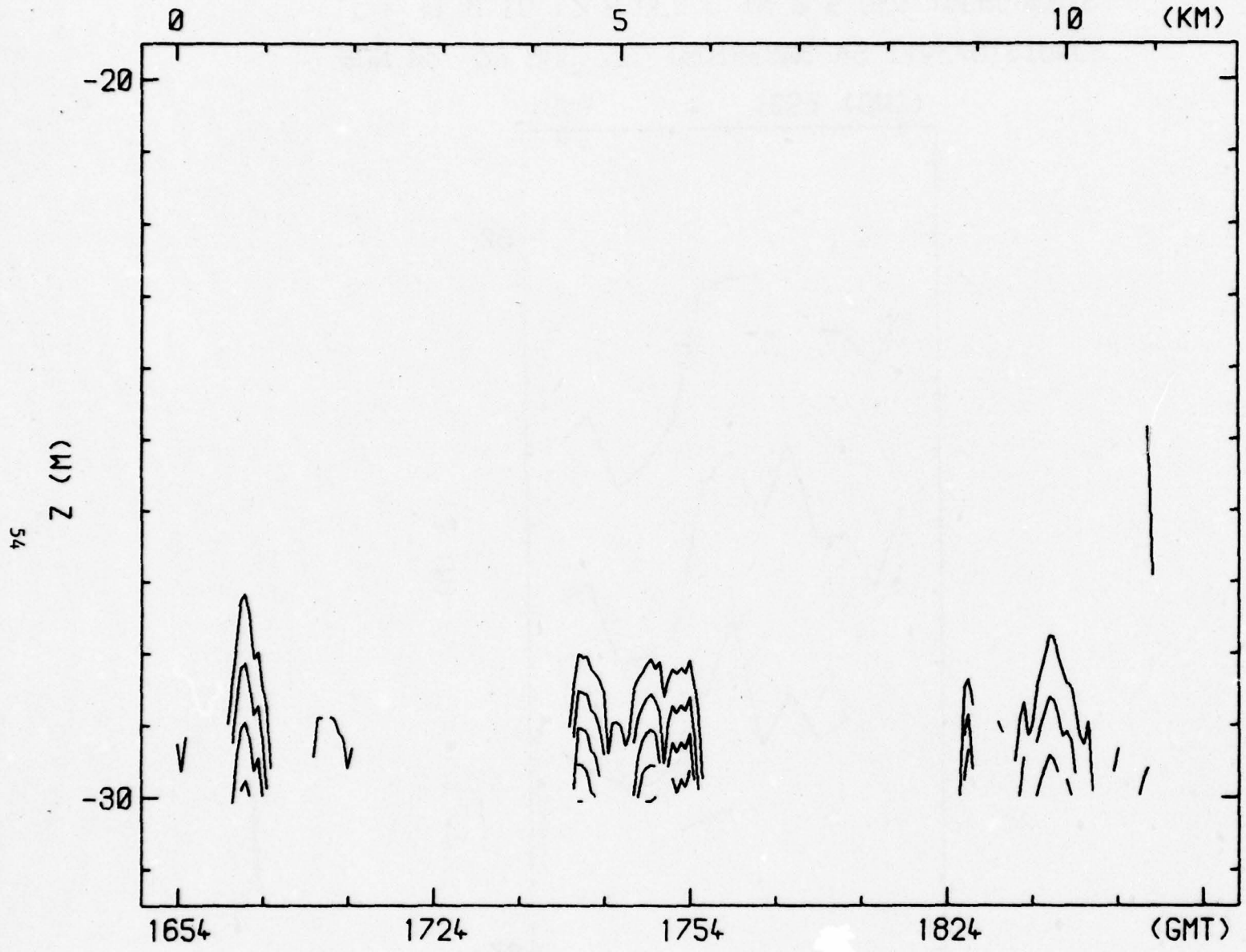
RUN 01 20 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



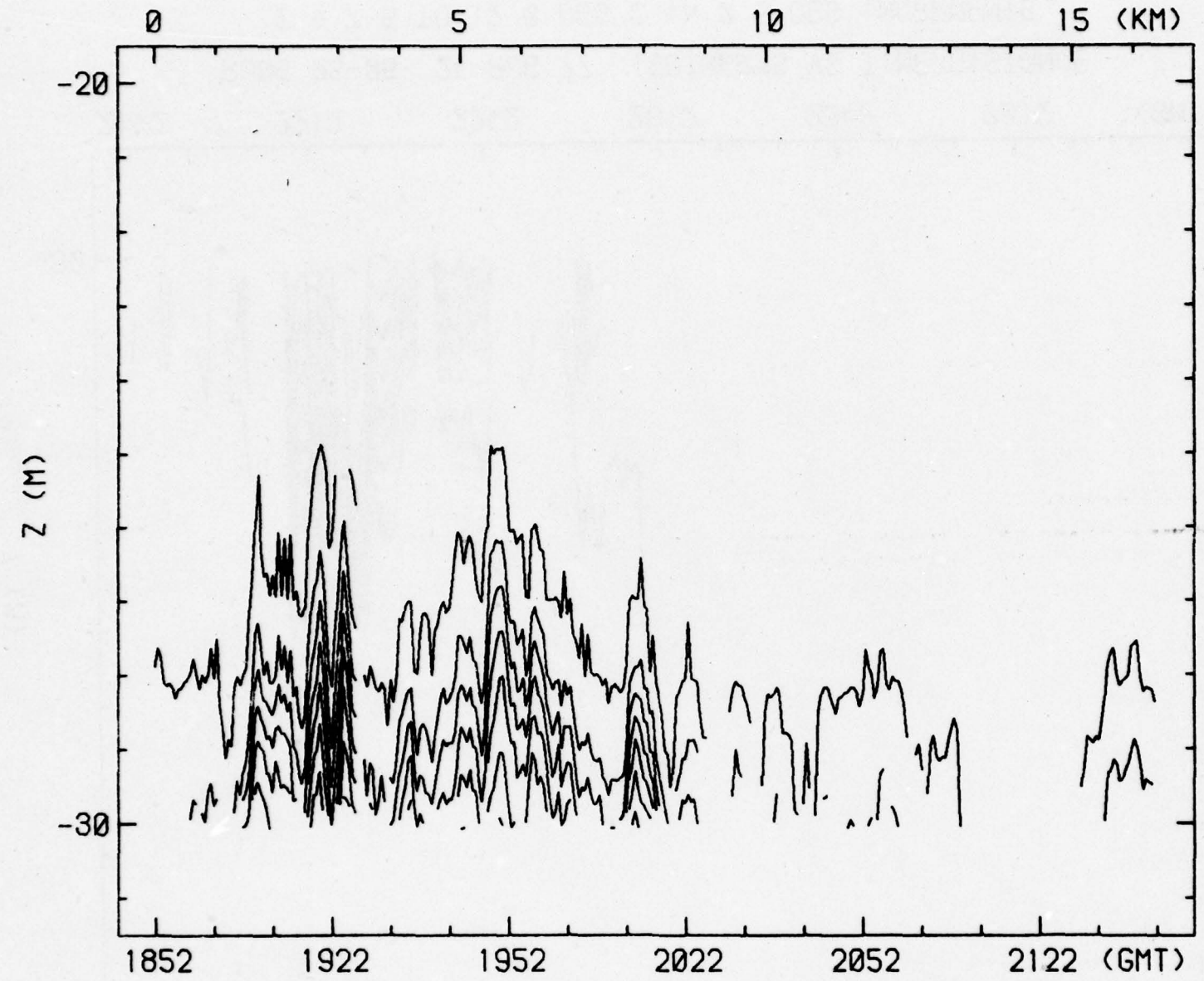
RUN 02 22 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 11.0 TO 12.5 DEG C IN 0.5 DEG INCREMENTS



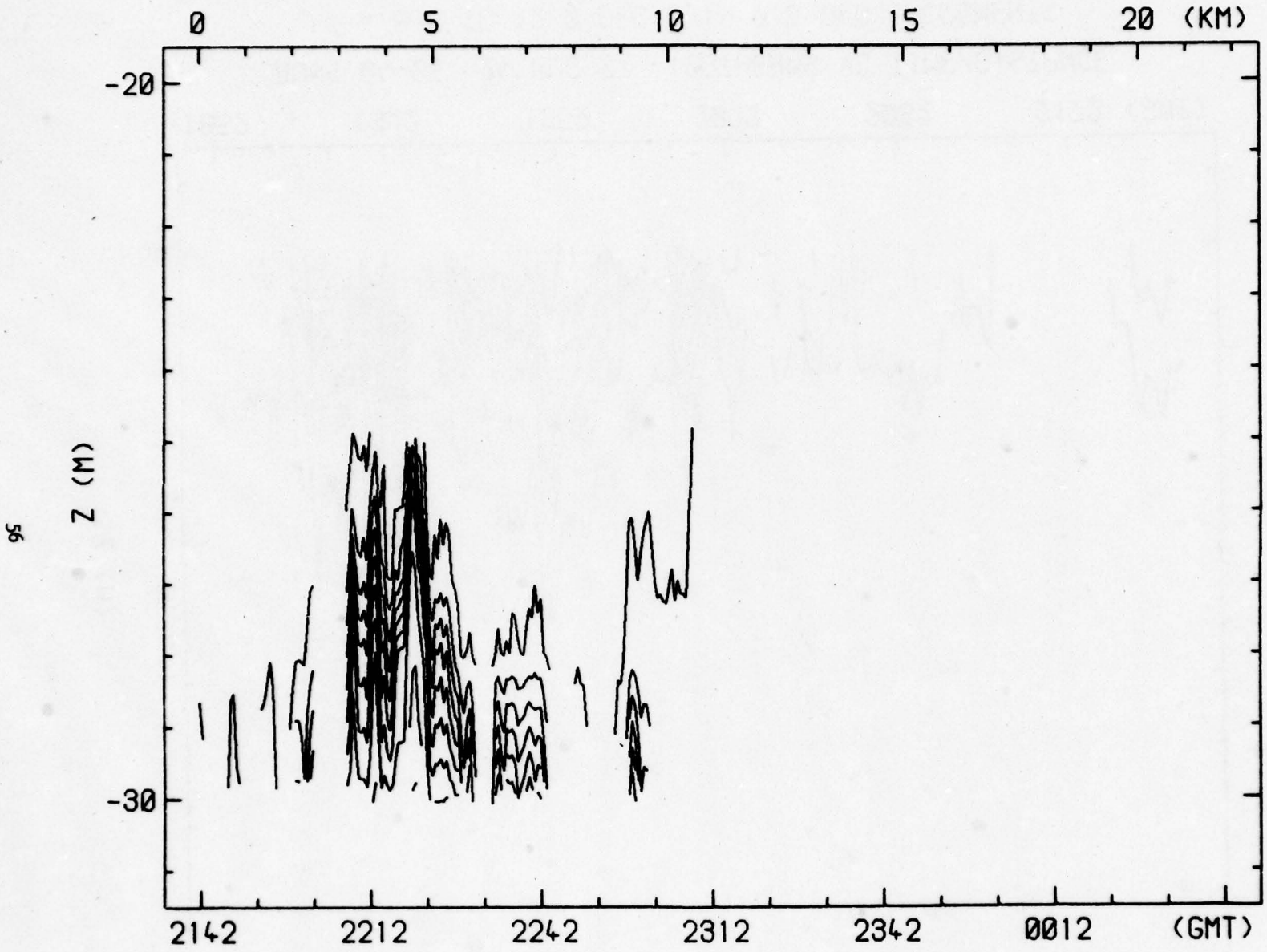
RUN 03 24 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 9.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



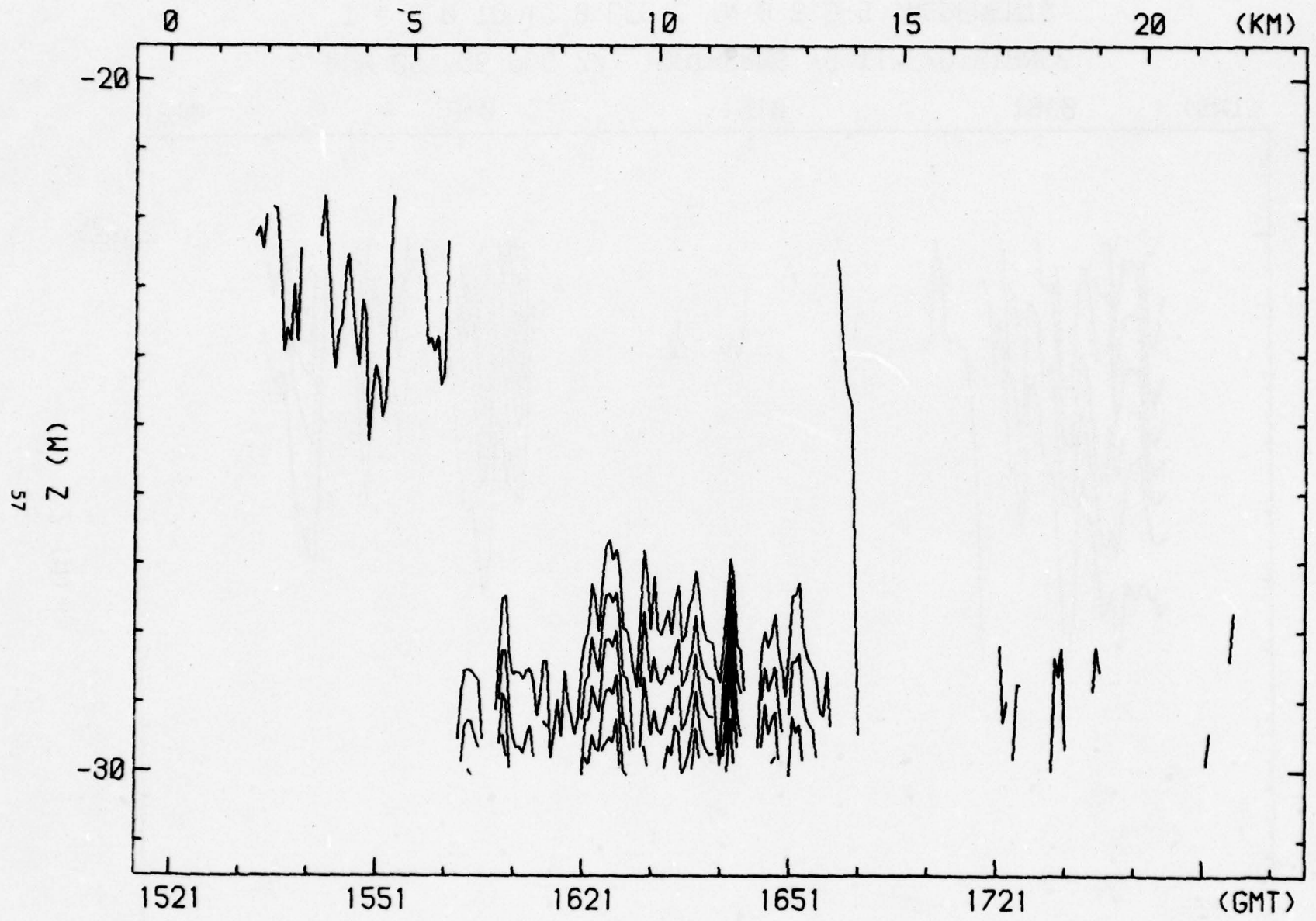
RUNS 04-05 24 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



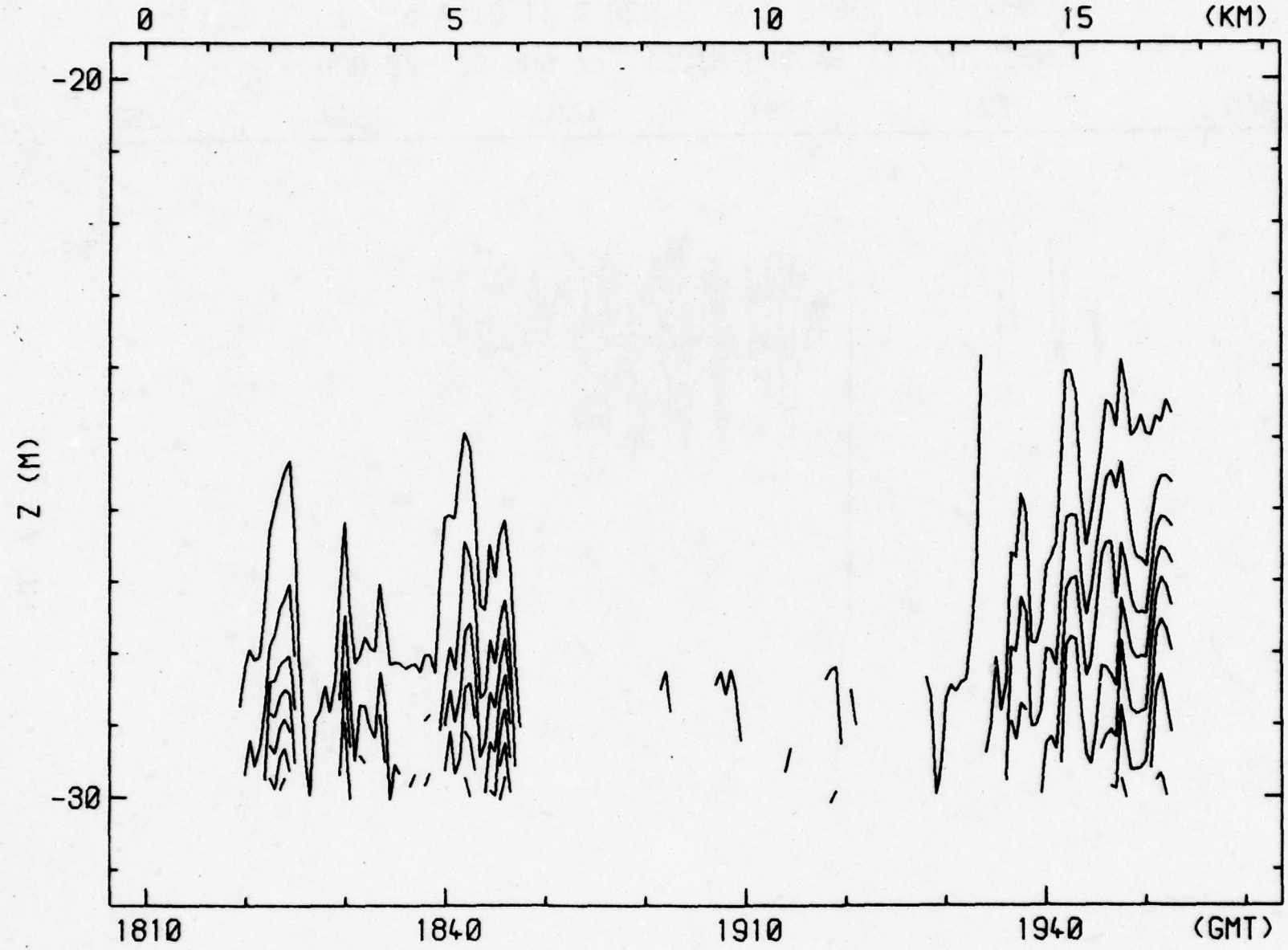
RUNS 05-06 24 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 7.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



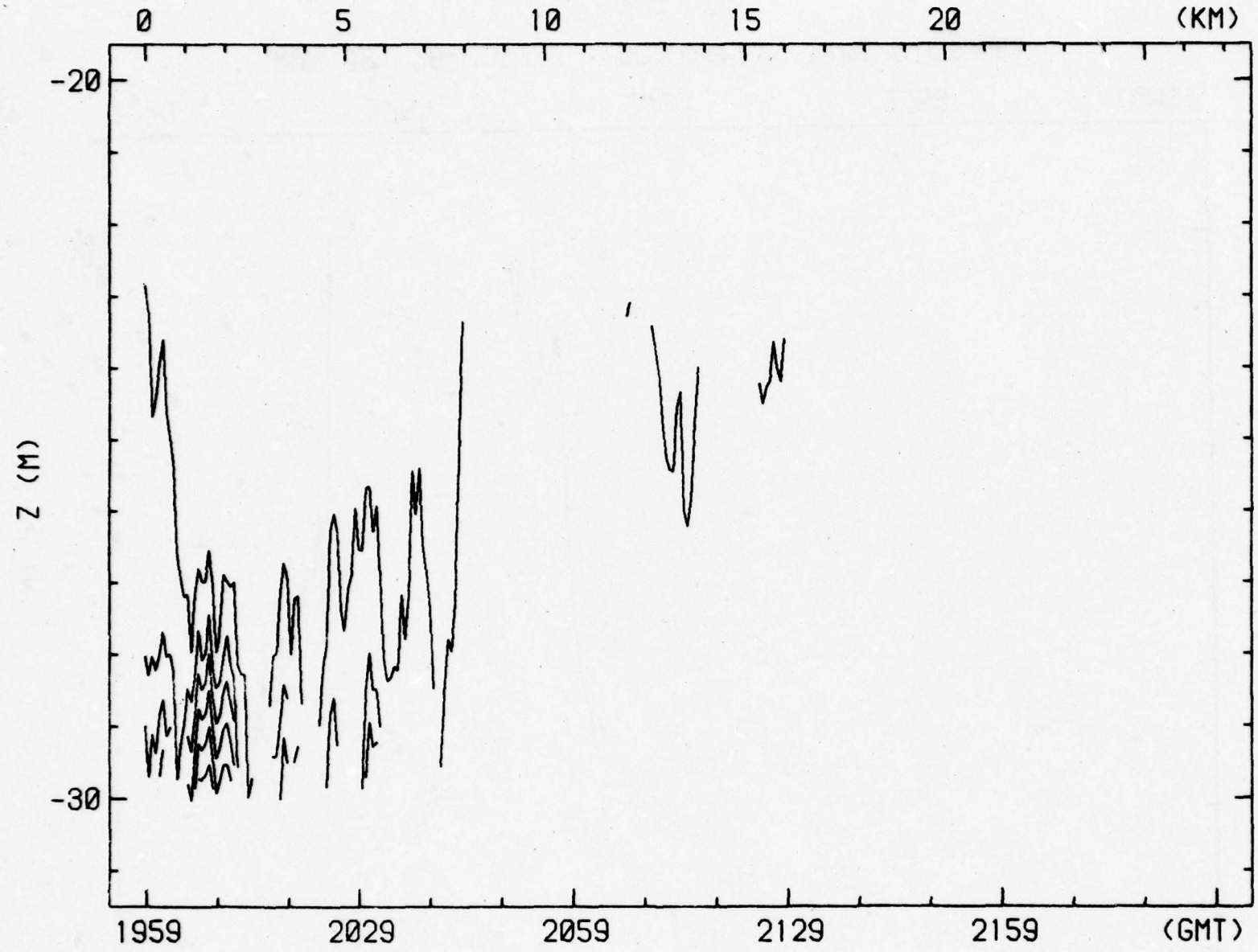
RUN 07 26 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 9.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



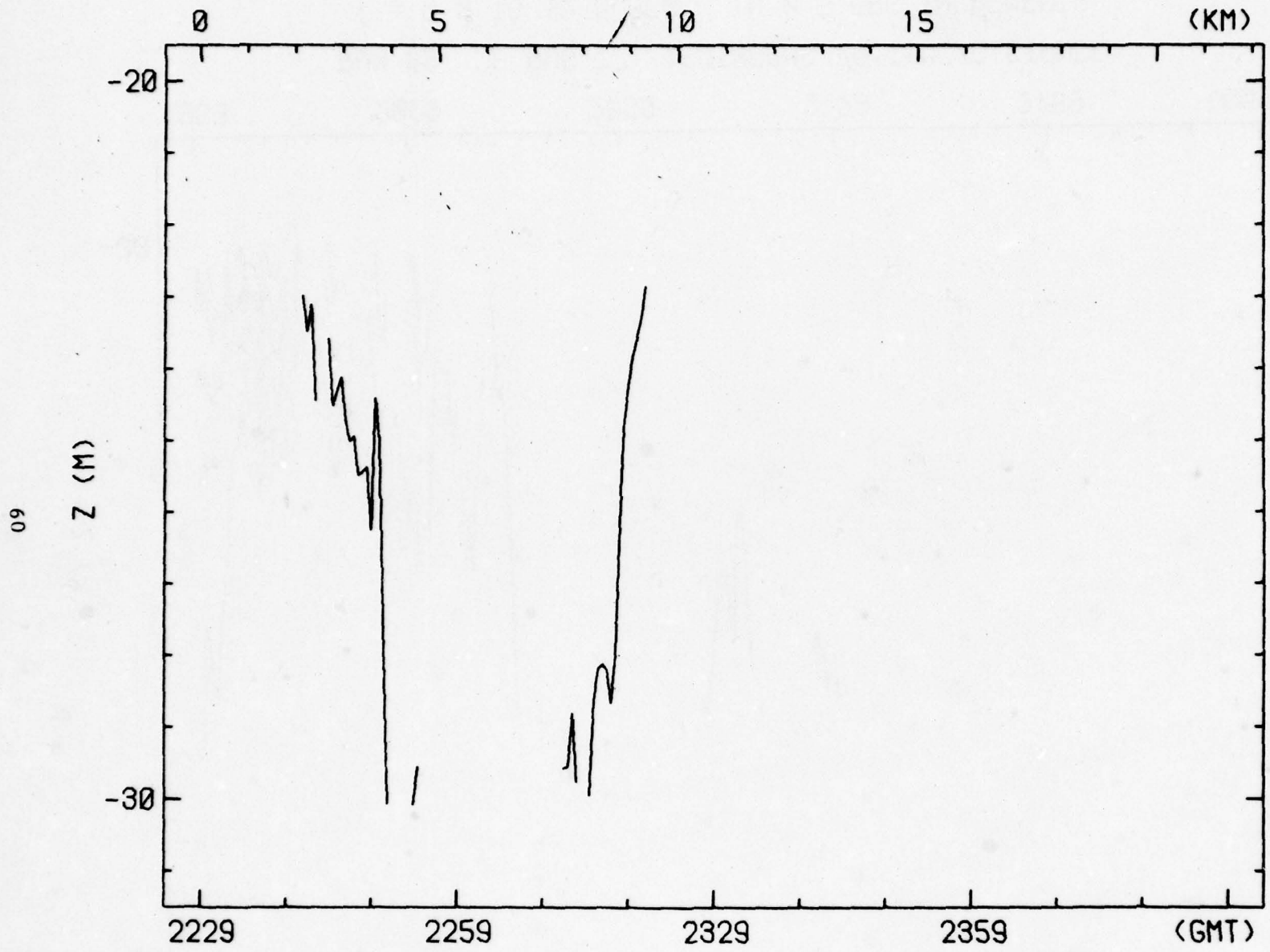
RUN 08 26 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



RUN 09 26 AUG 77 ISOTHERMS VS TIME/DISTANCE

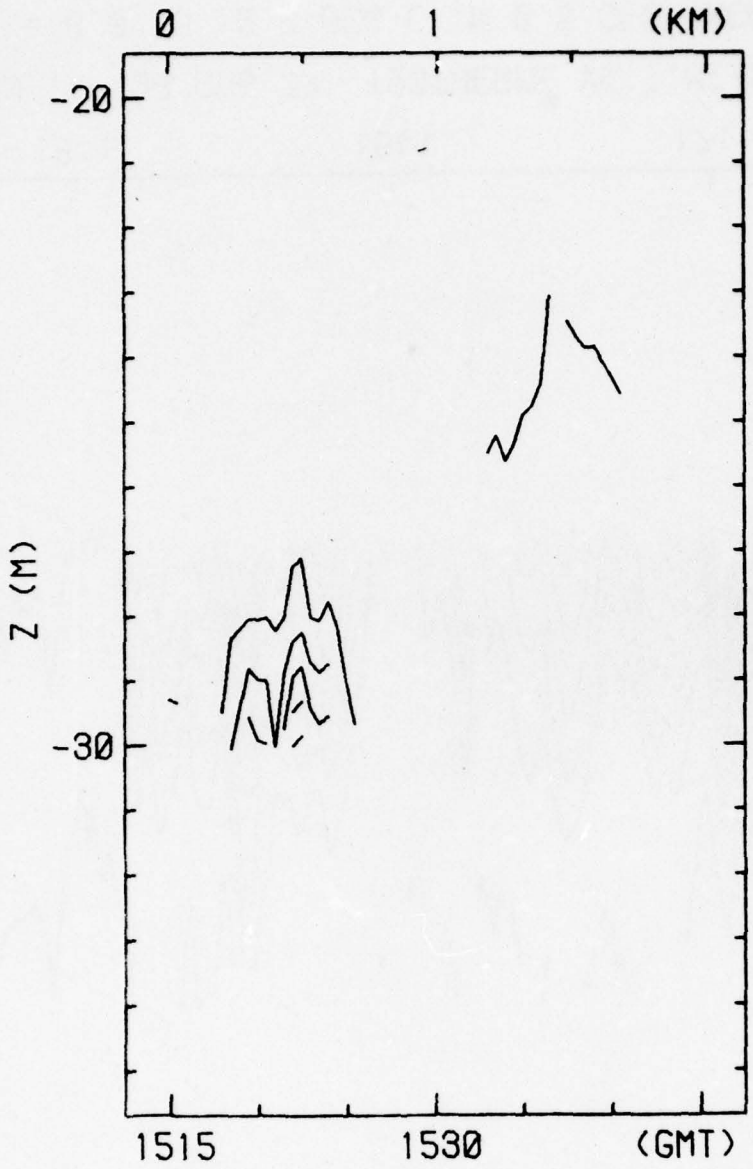
T = 9.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



09

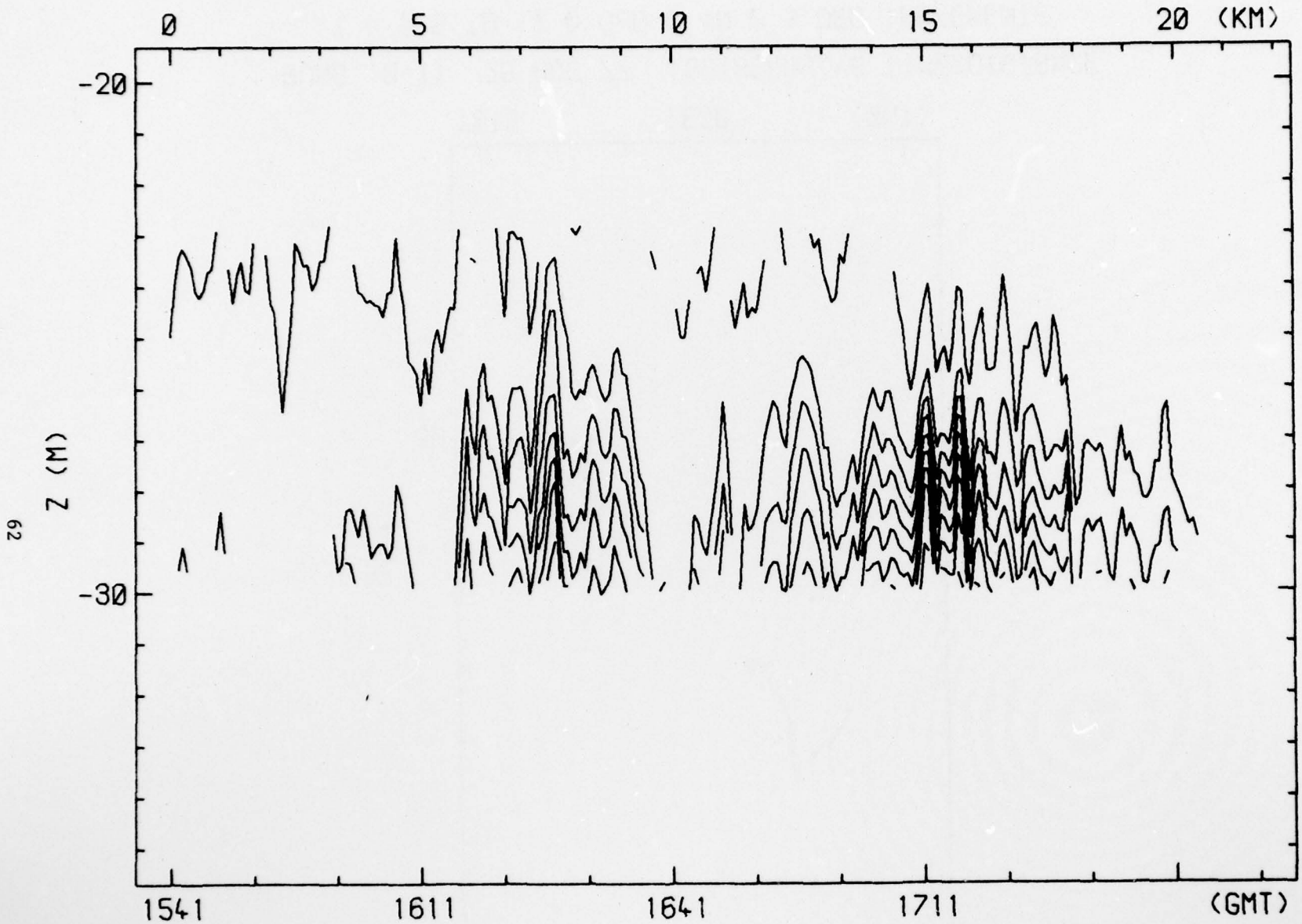
RUN 09 26 AUG 77 ISOTHERM VS TIME/DISTANCE

T = 12.0 DEG C



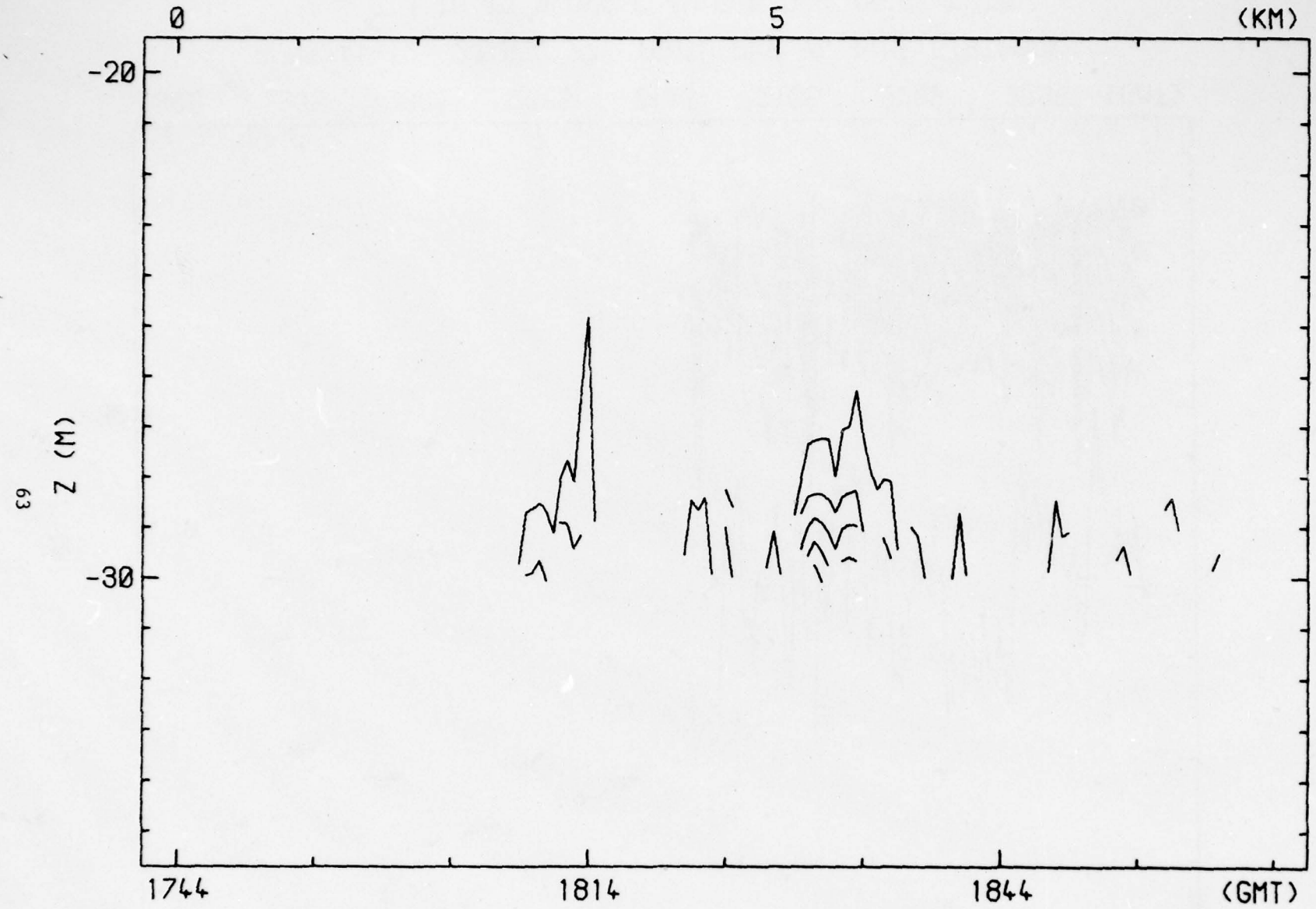
RUNS 10-11 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 9.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



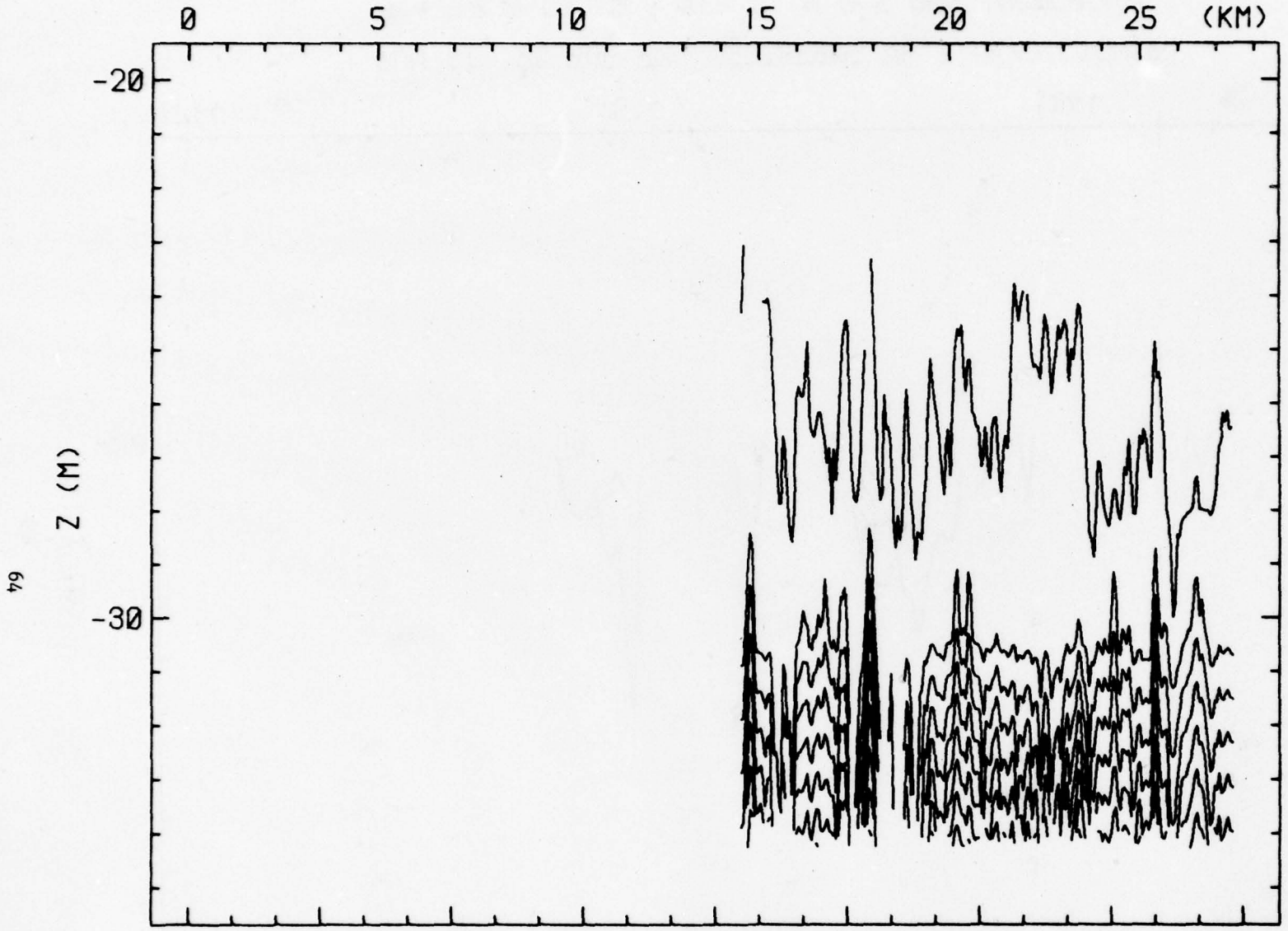
RUN 11 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



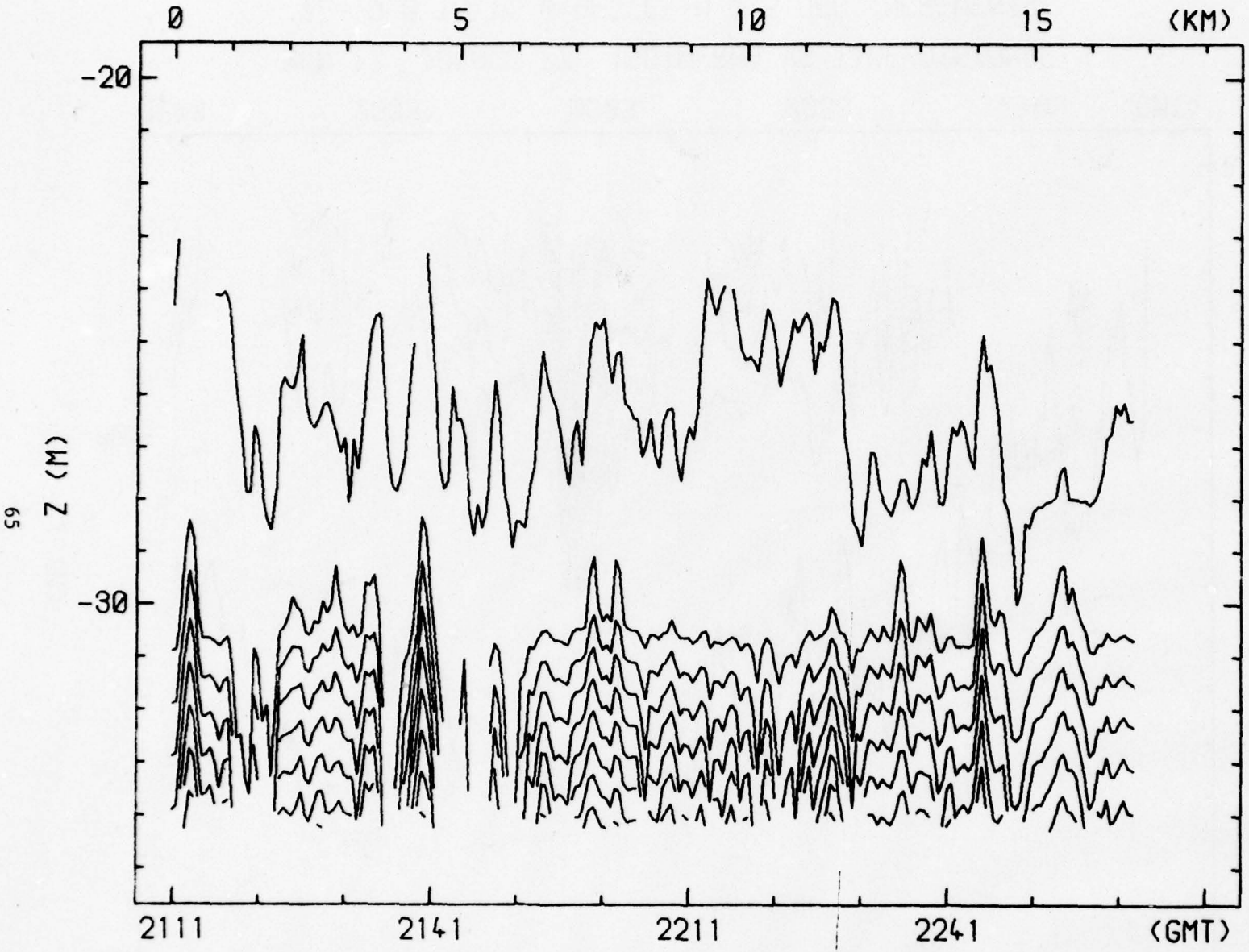
RUN 11 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 10.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



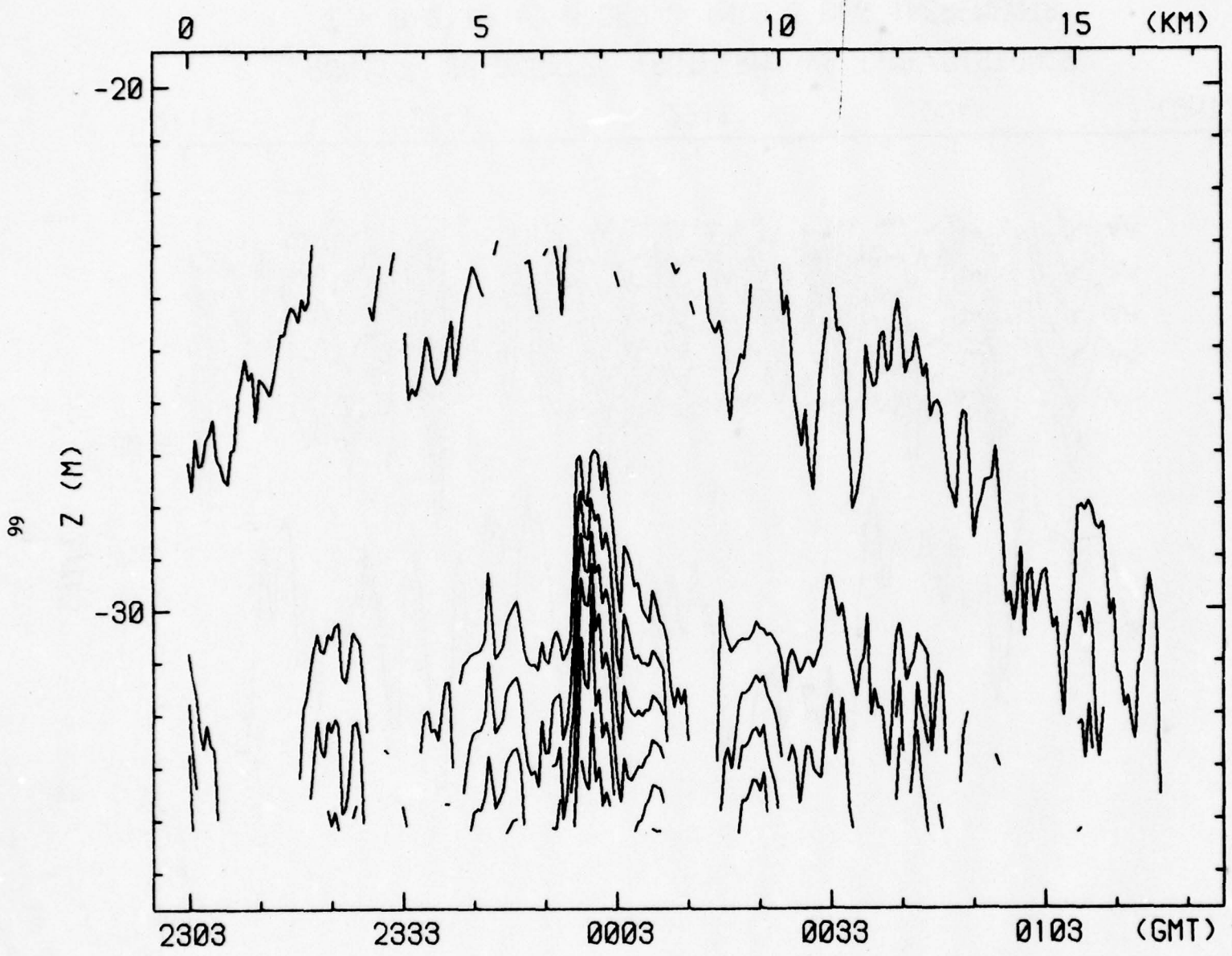
RUNS 11-12 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



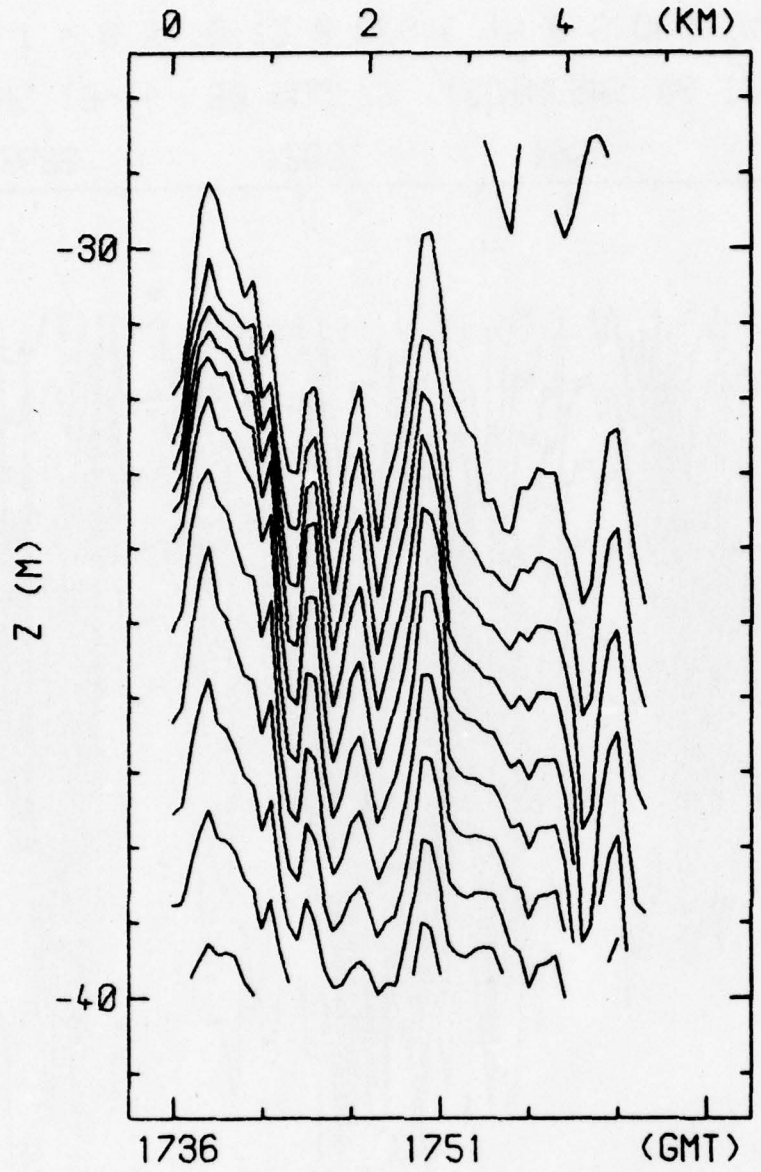
RUN 12 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



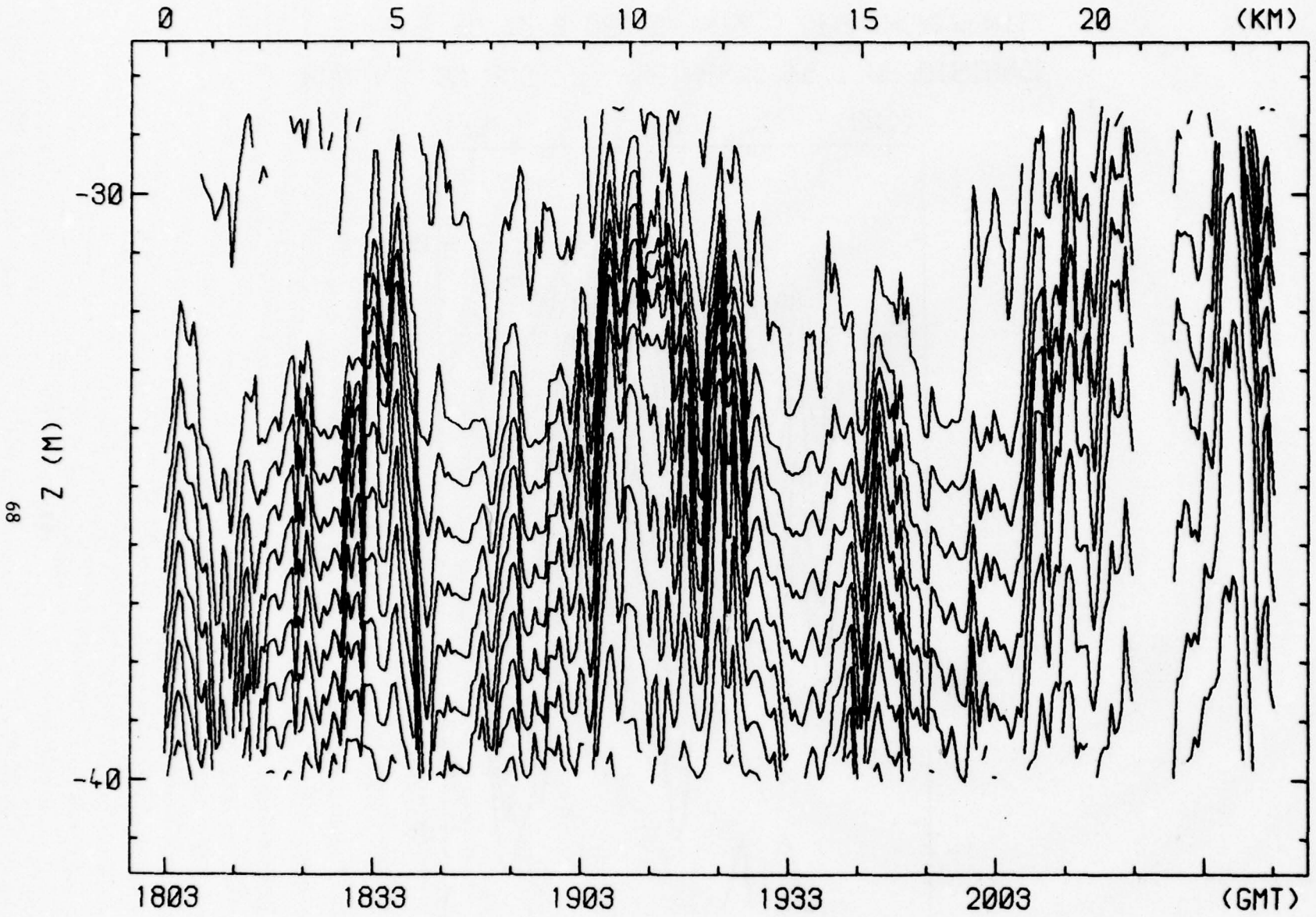
RUN 12 28 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 9.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



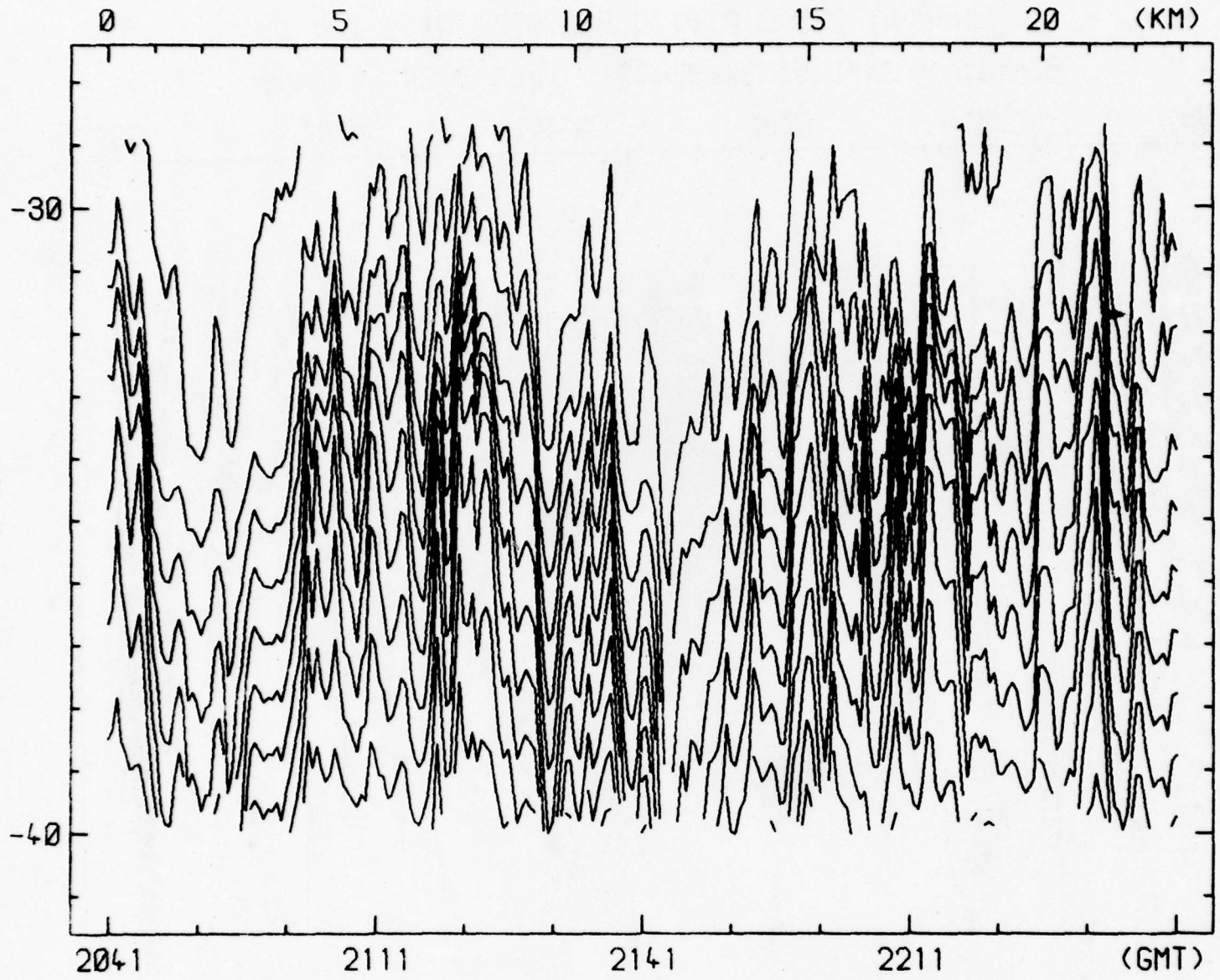
RUN 13 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



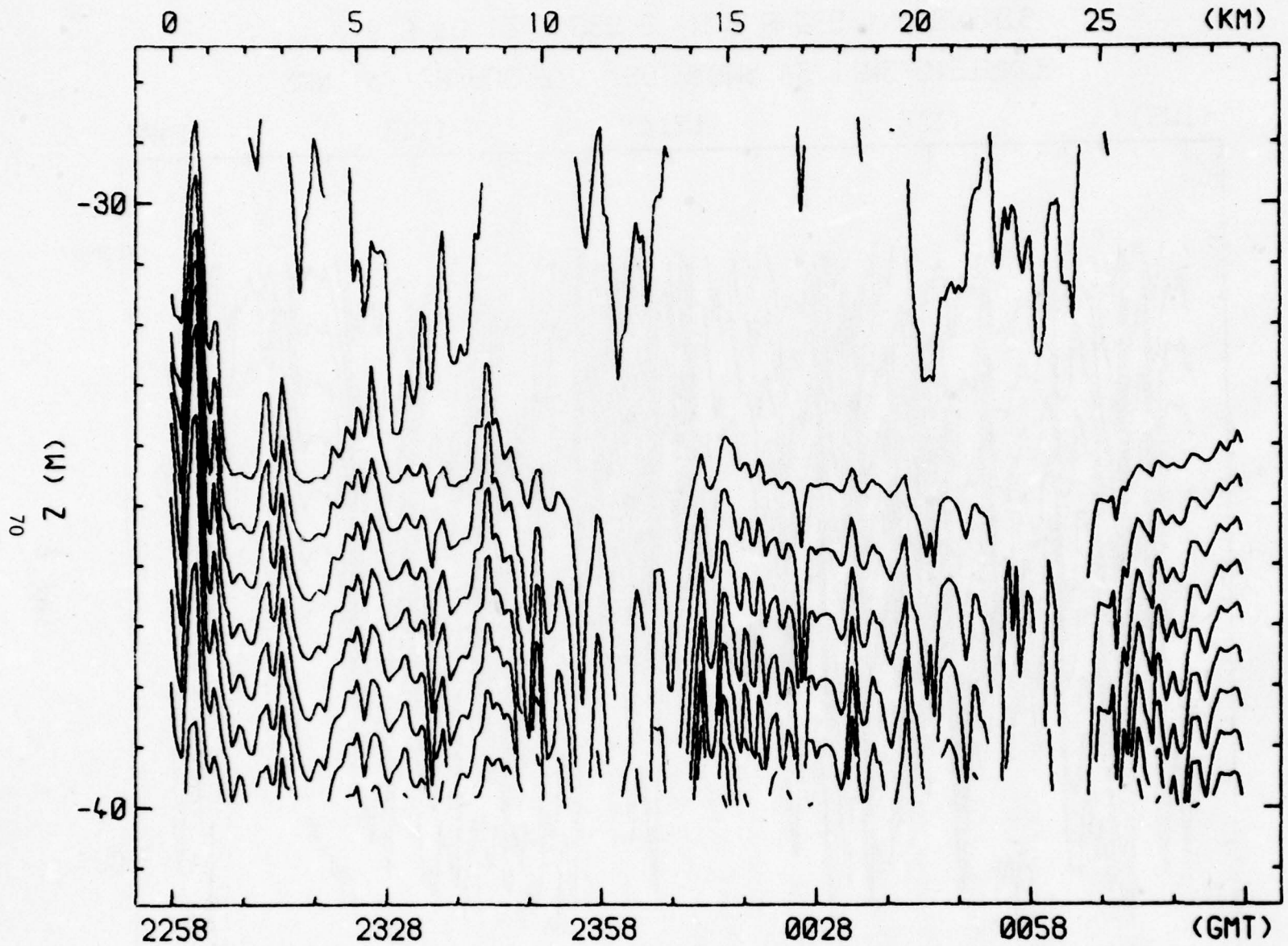
RUNS 13-14 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



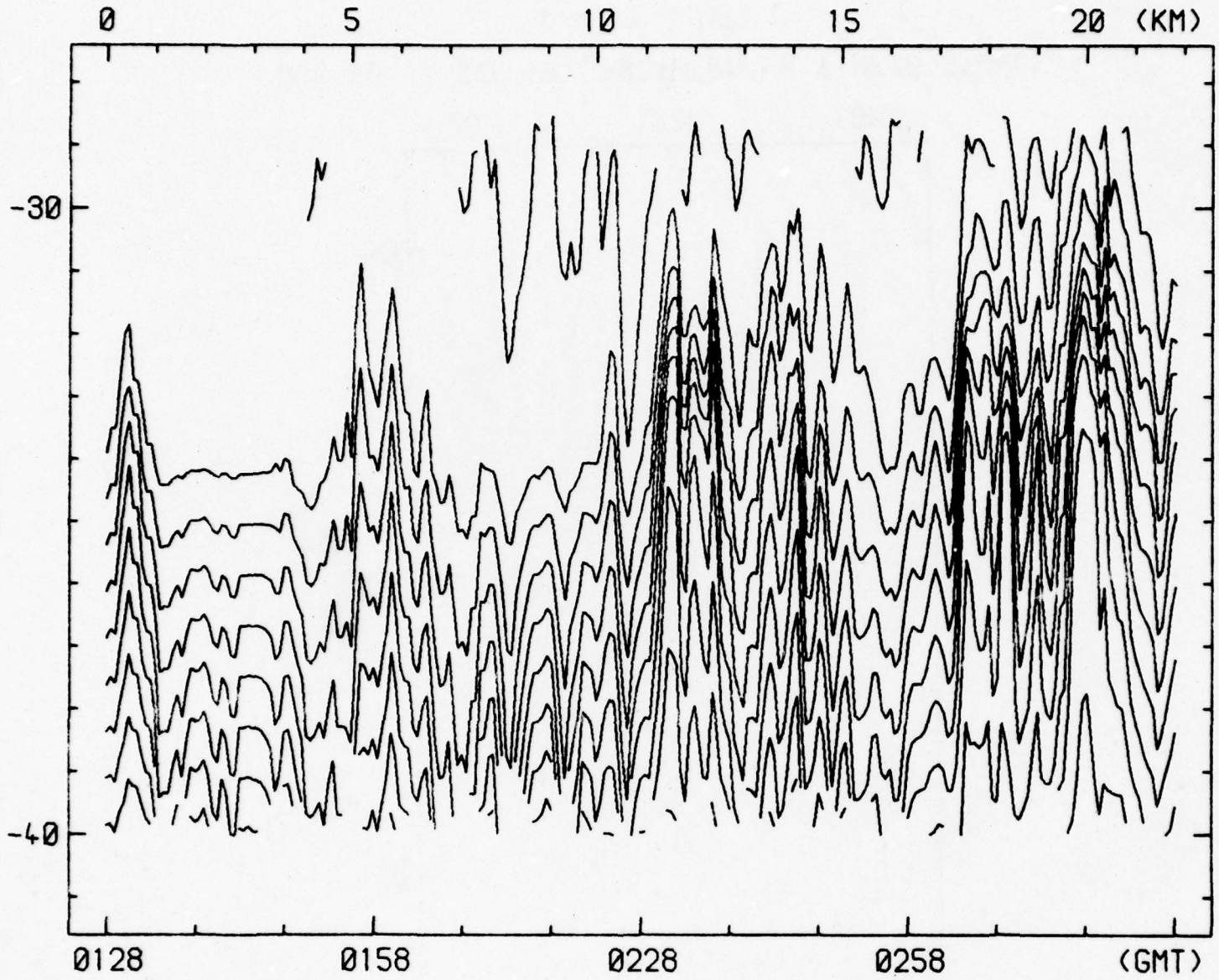
RUN 14 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



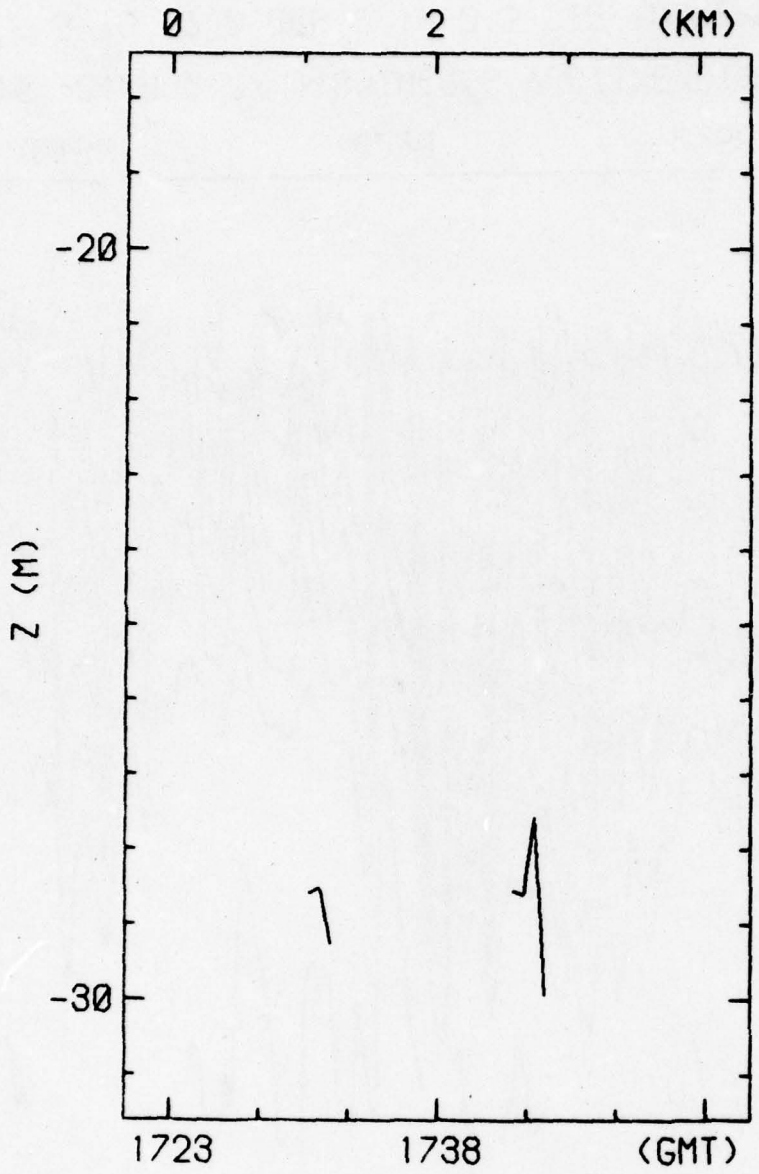
RUN 15 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 7.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



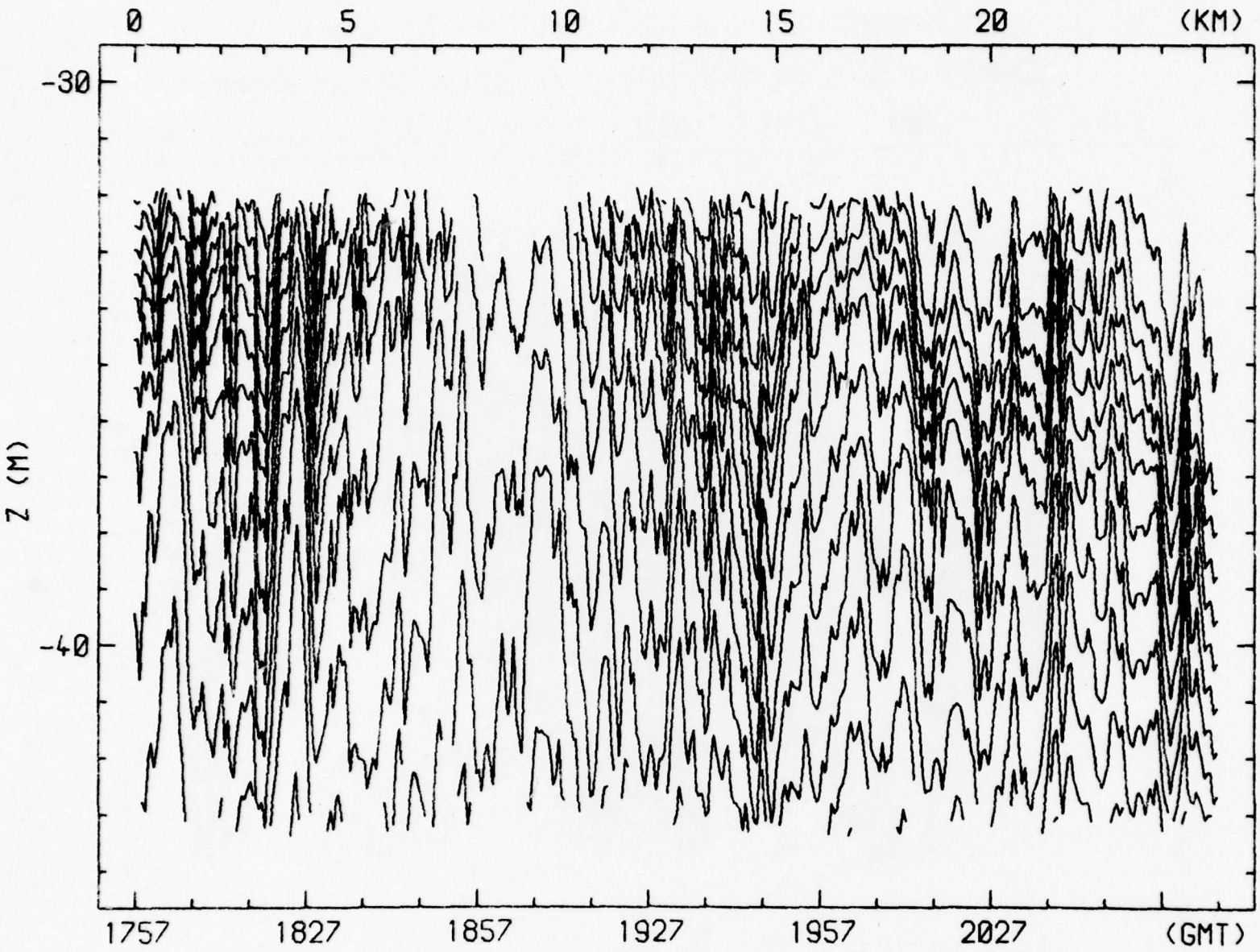
RUN 15 31 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



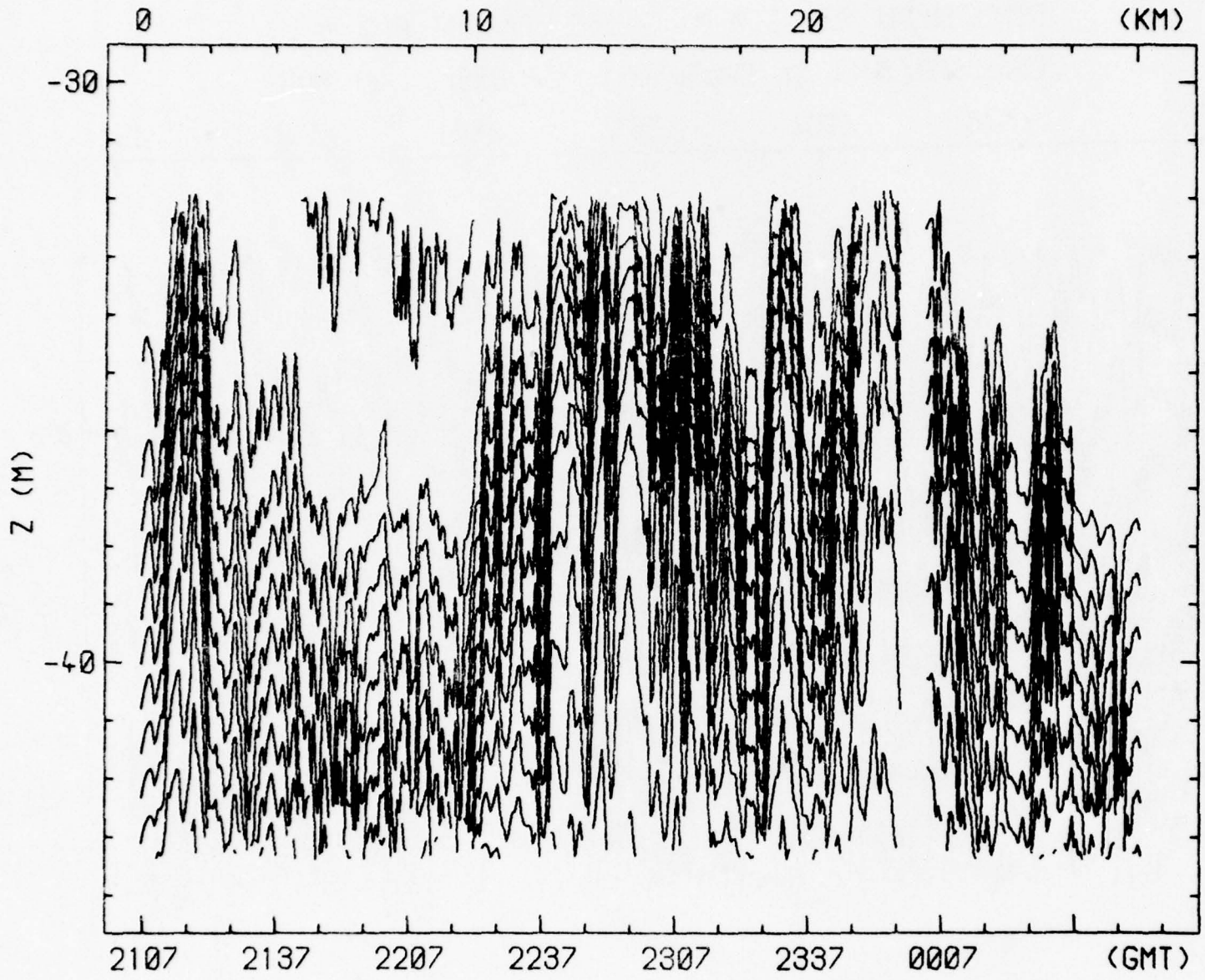
RUN 16 1 SEP 77 ISOTHERM VS TIME/DISTANCE

T = 12.0 DEG C



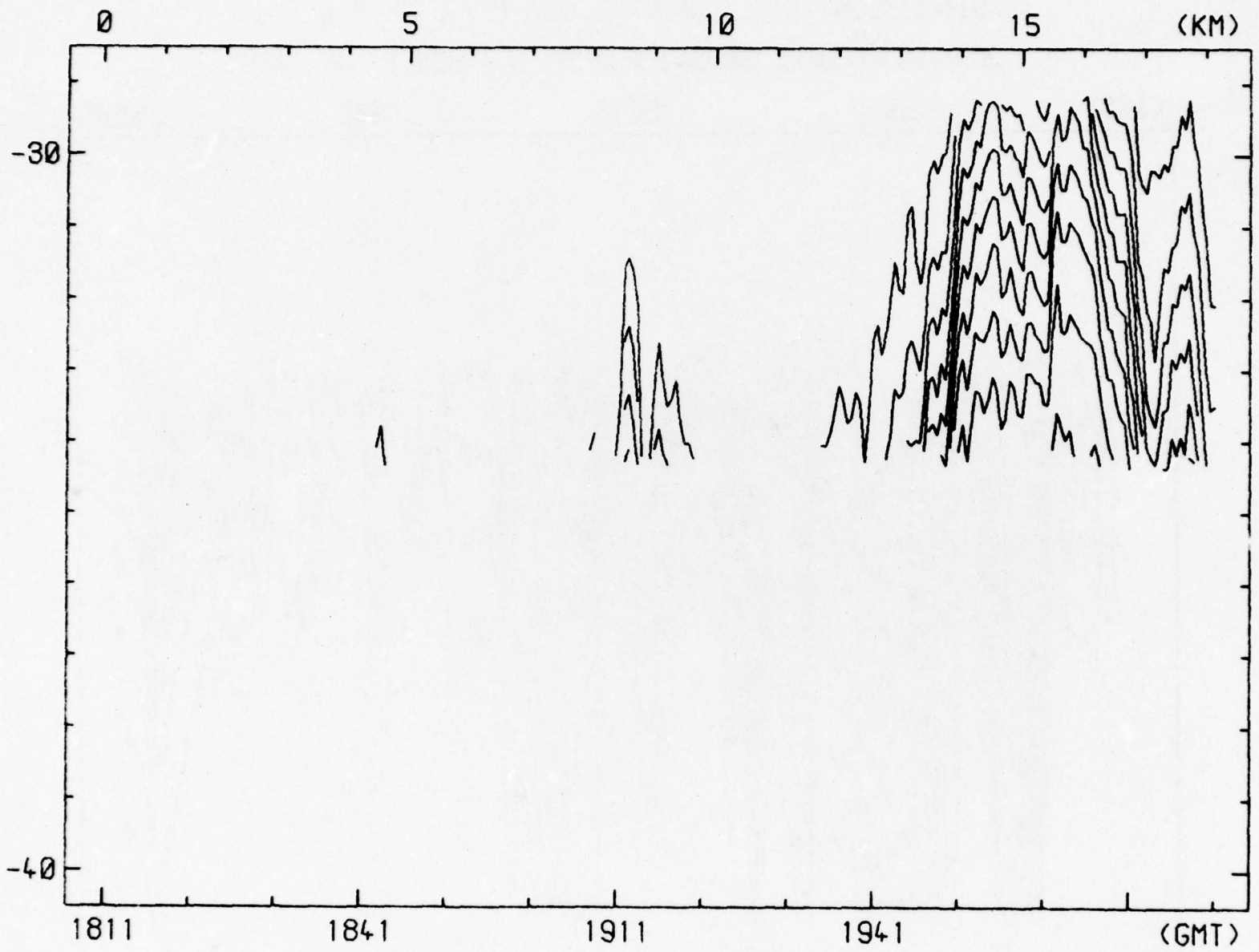
RUN 17 1 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 6.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



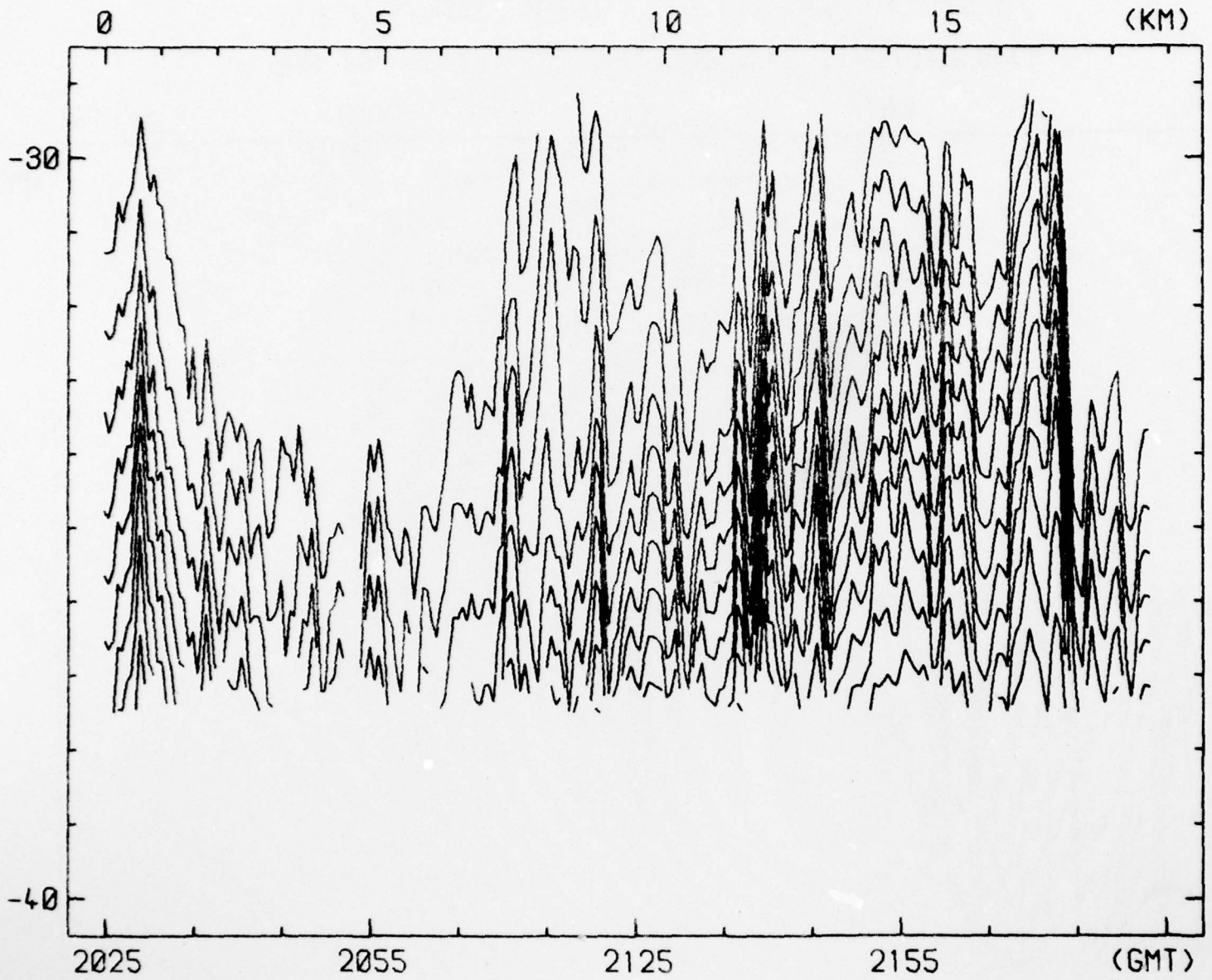
RUNS 17-18 1 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.5 DEG C IN 0.5 DEG INCREMENTS



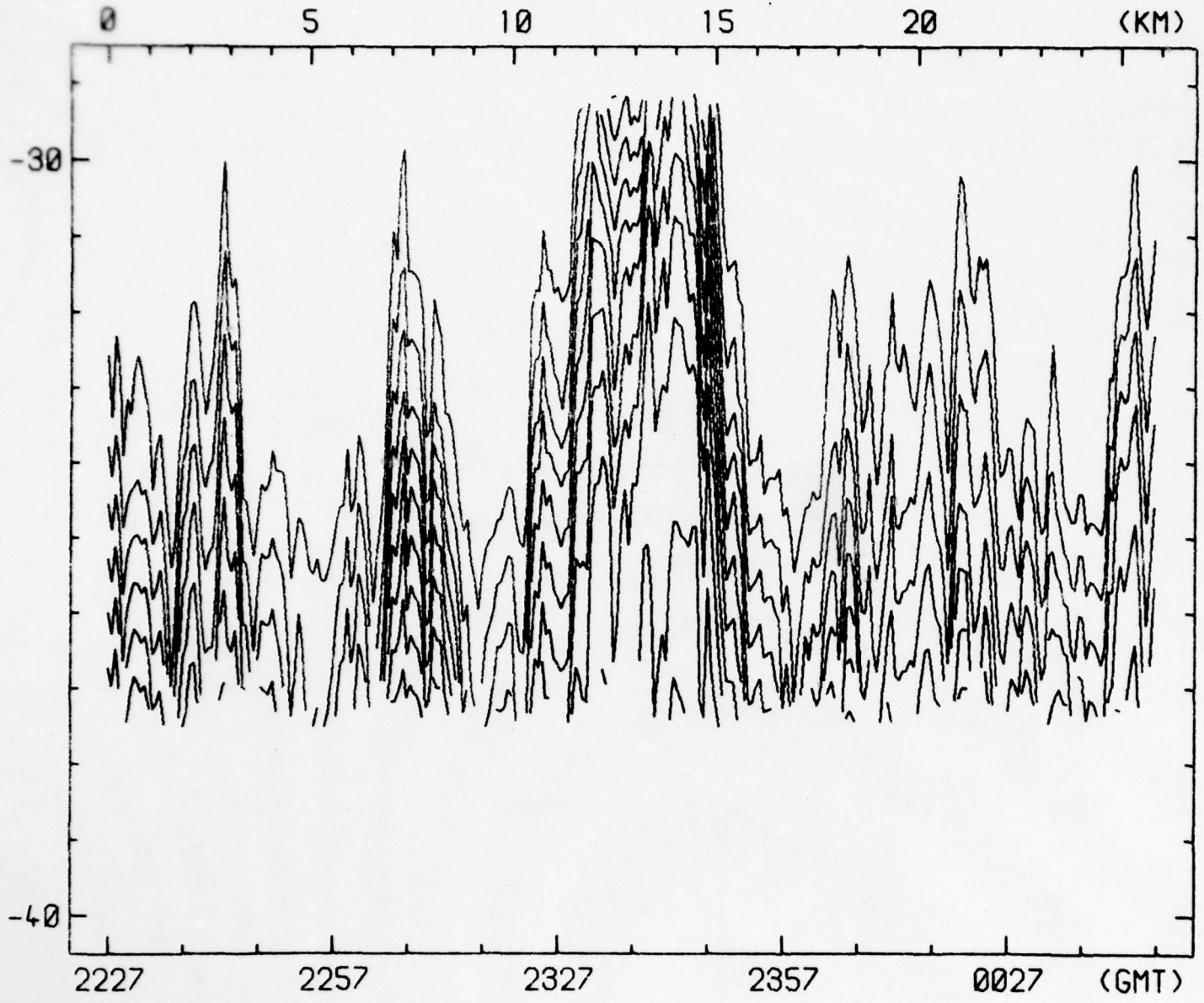
RUN 19 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



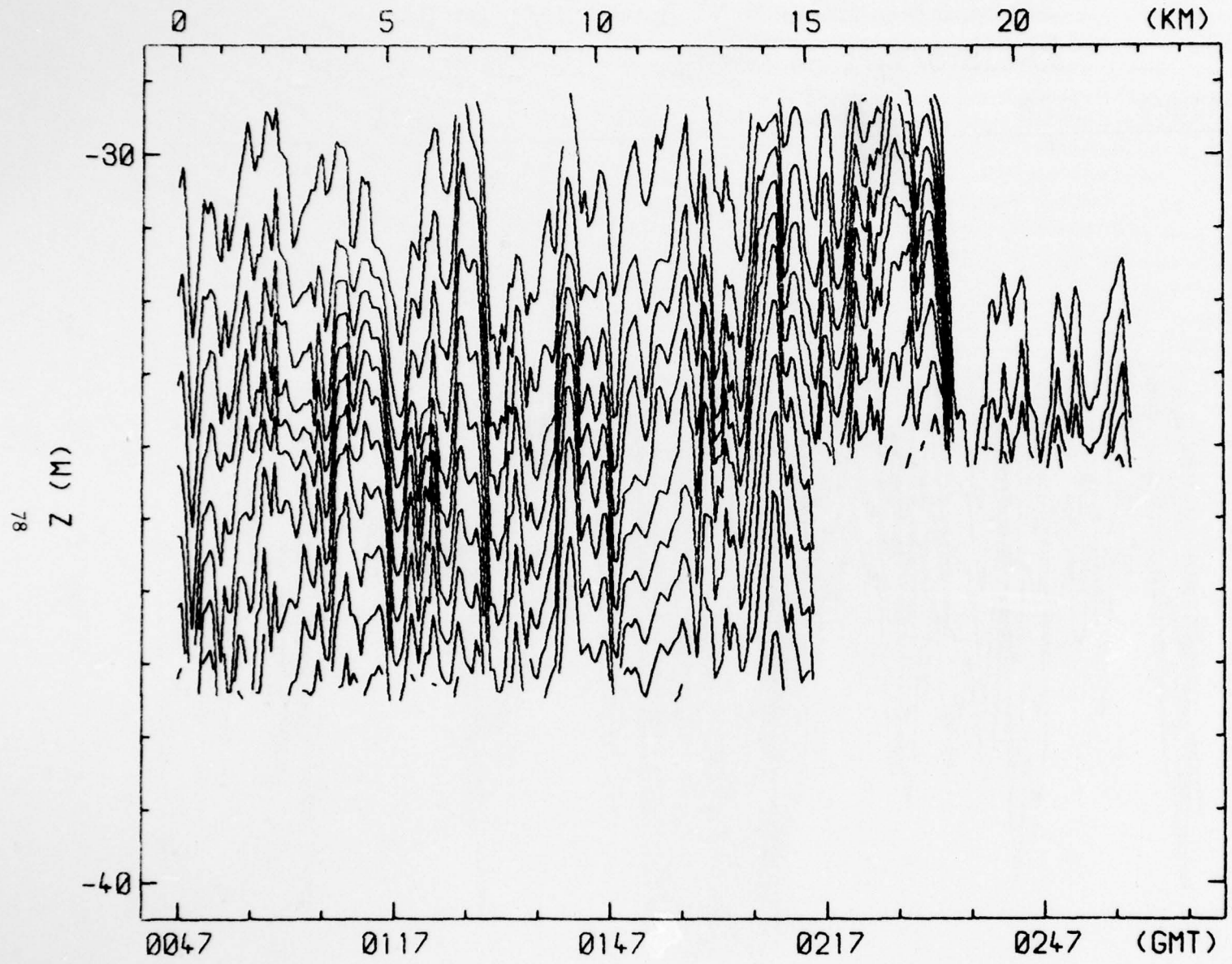
RUN 20 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



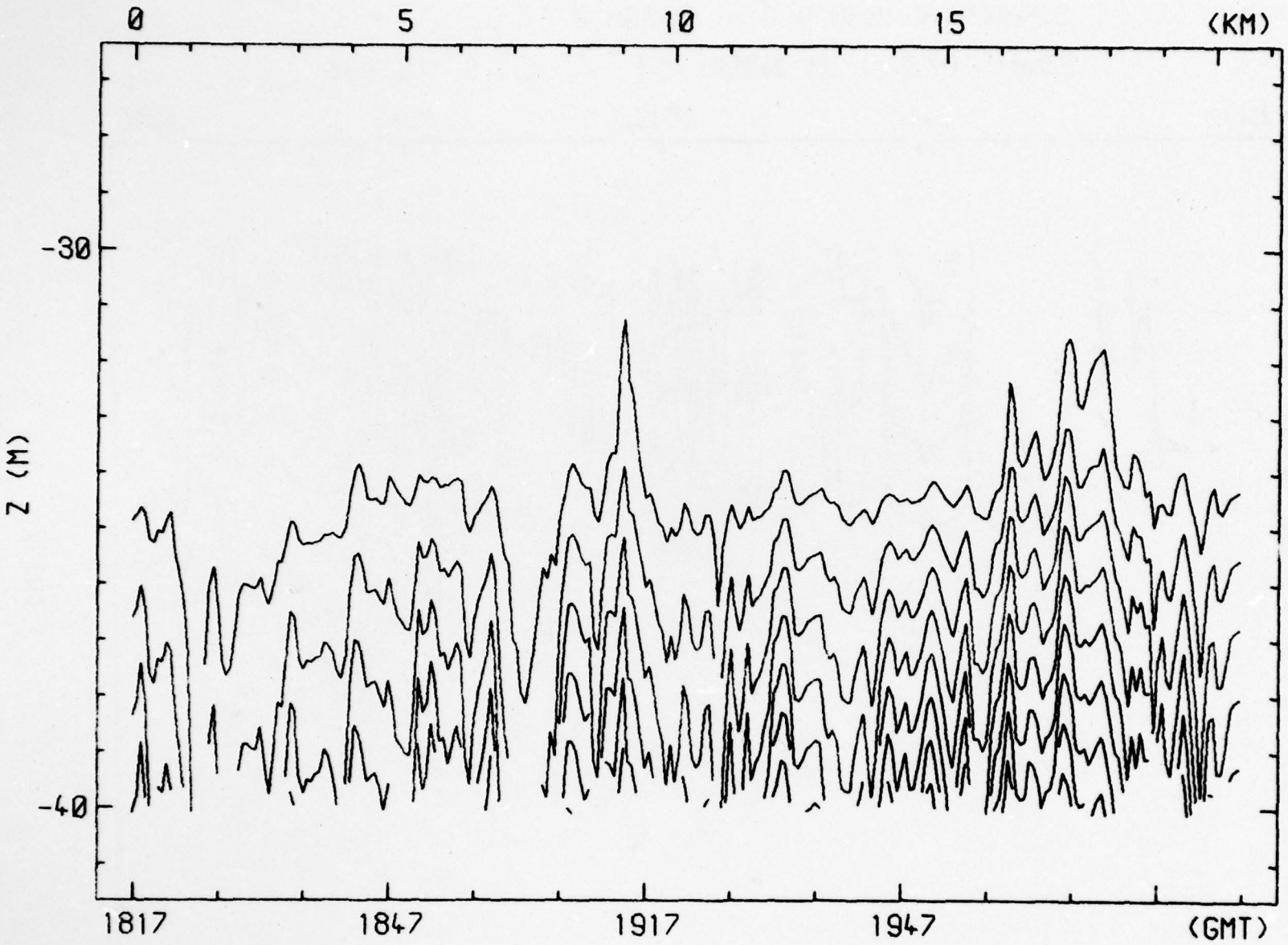
RUN 21 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



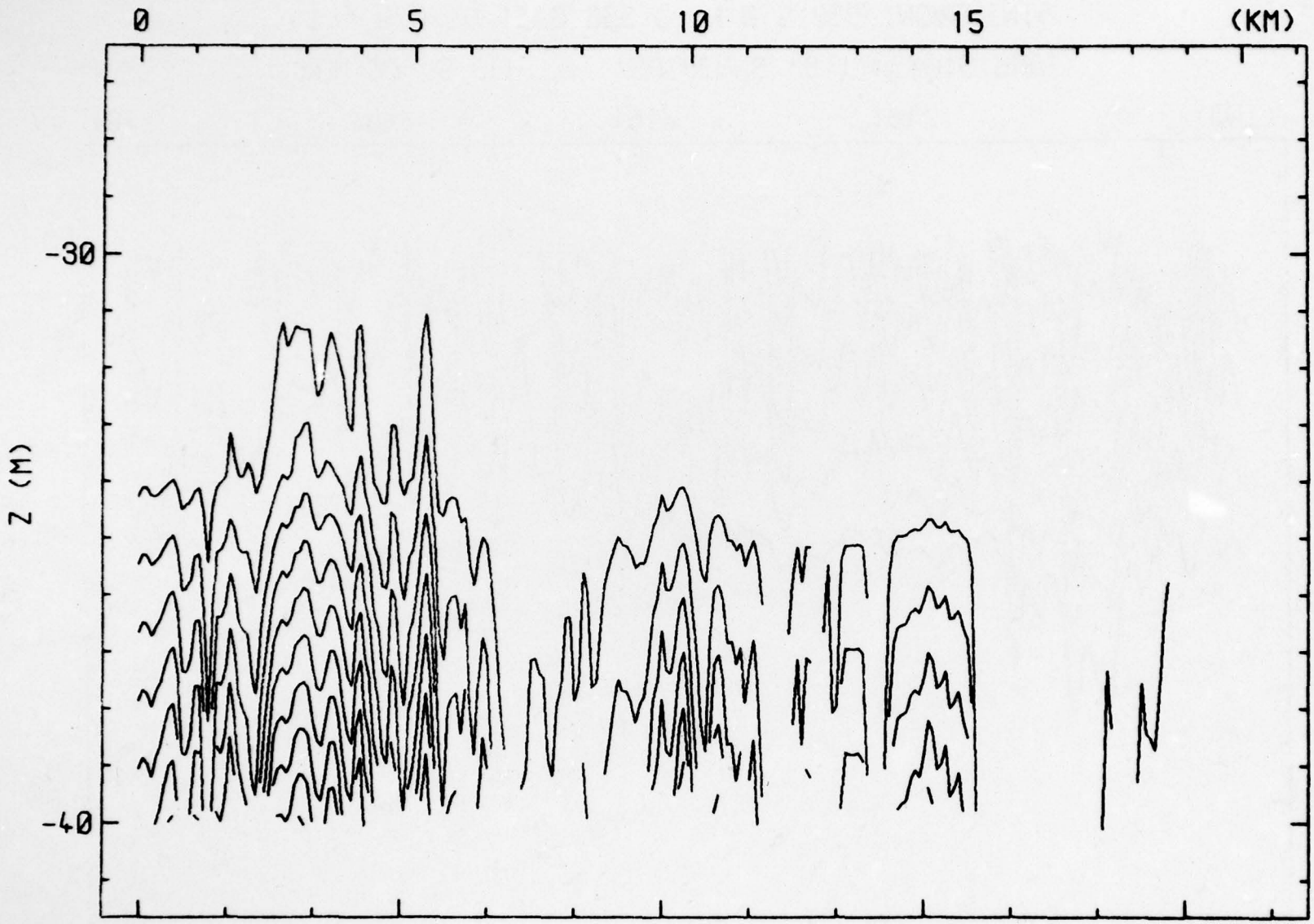
RUN 21 4 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



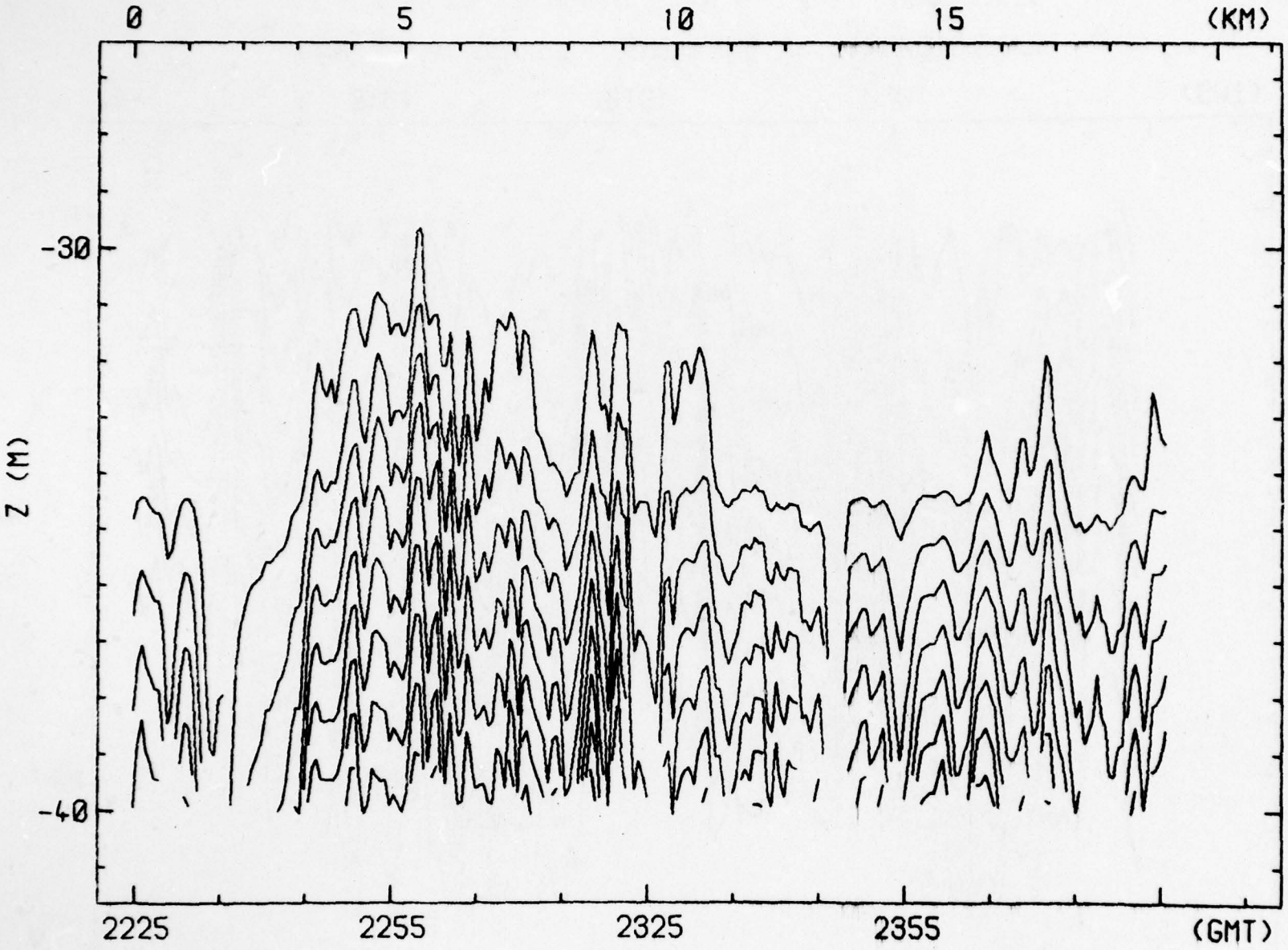
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



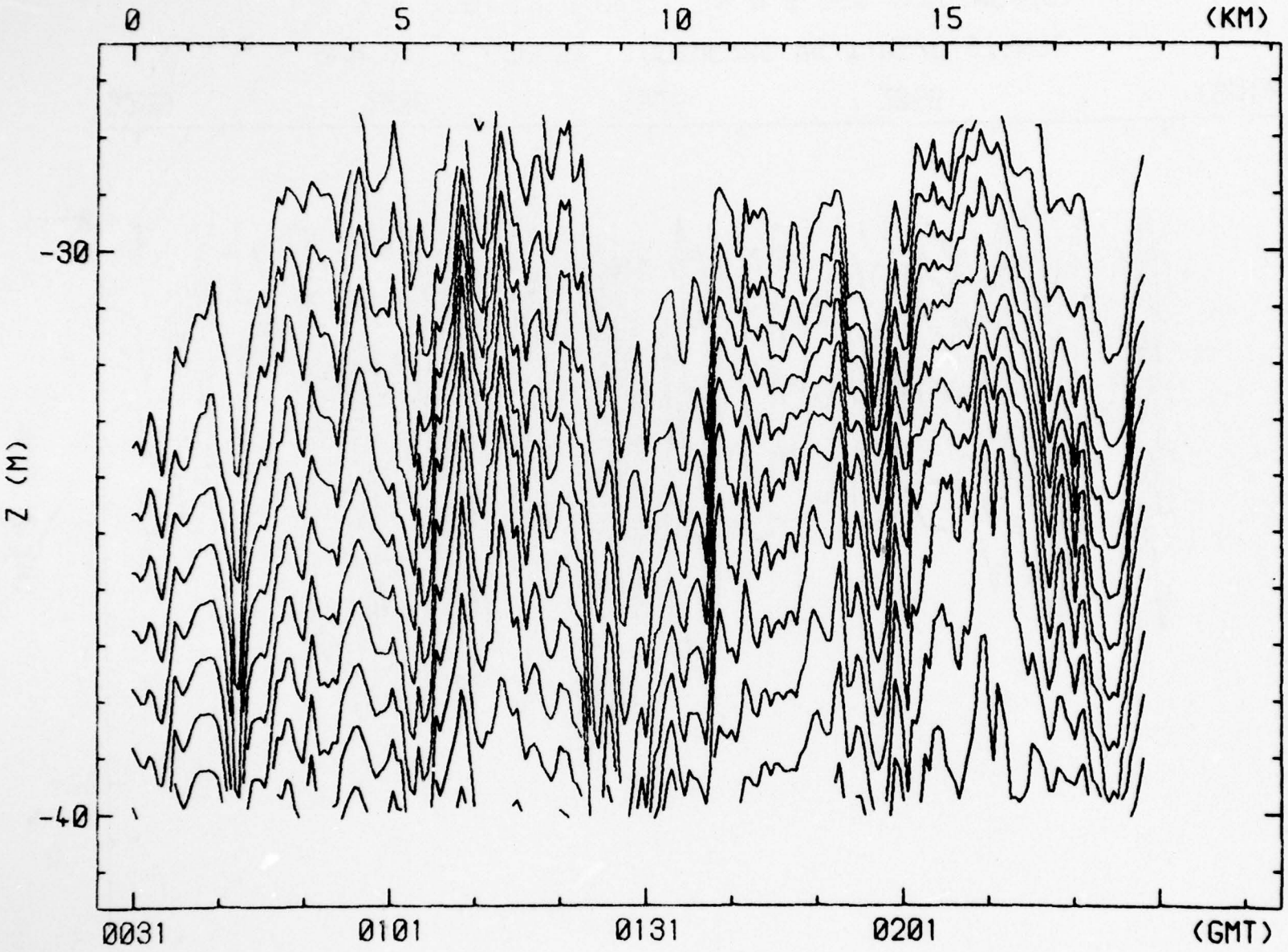
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



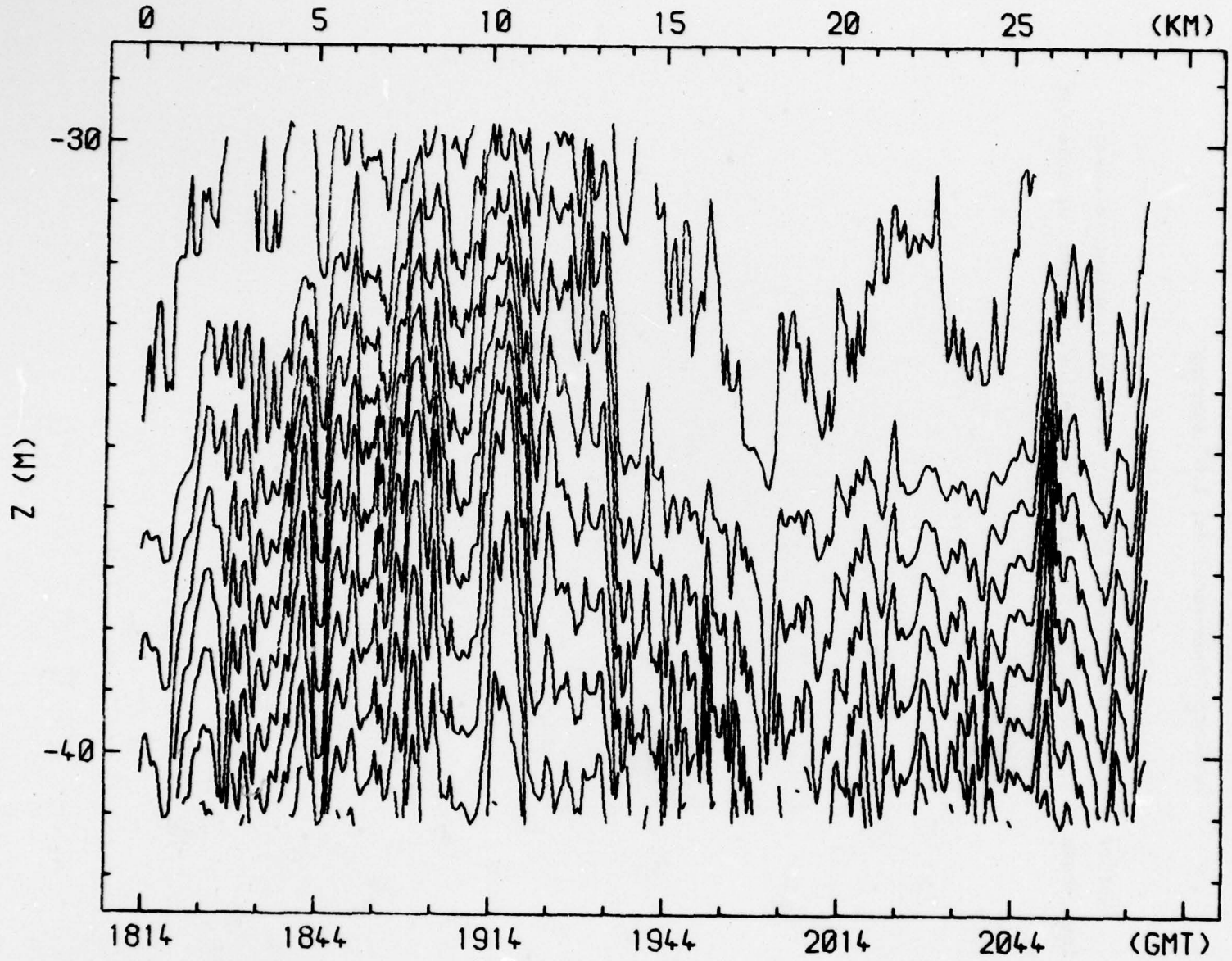
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



RUN 23 6 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.0 DEG C IN 0.5 DEG INCREMENTS



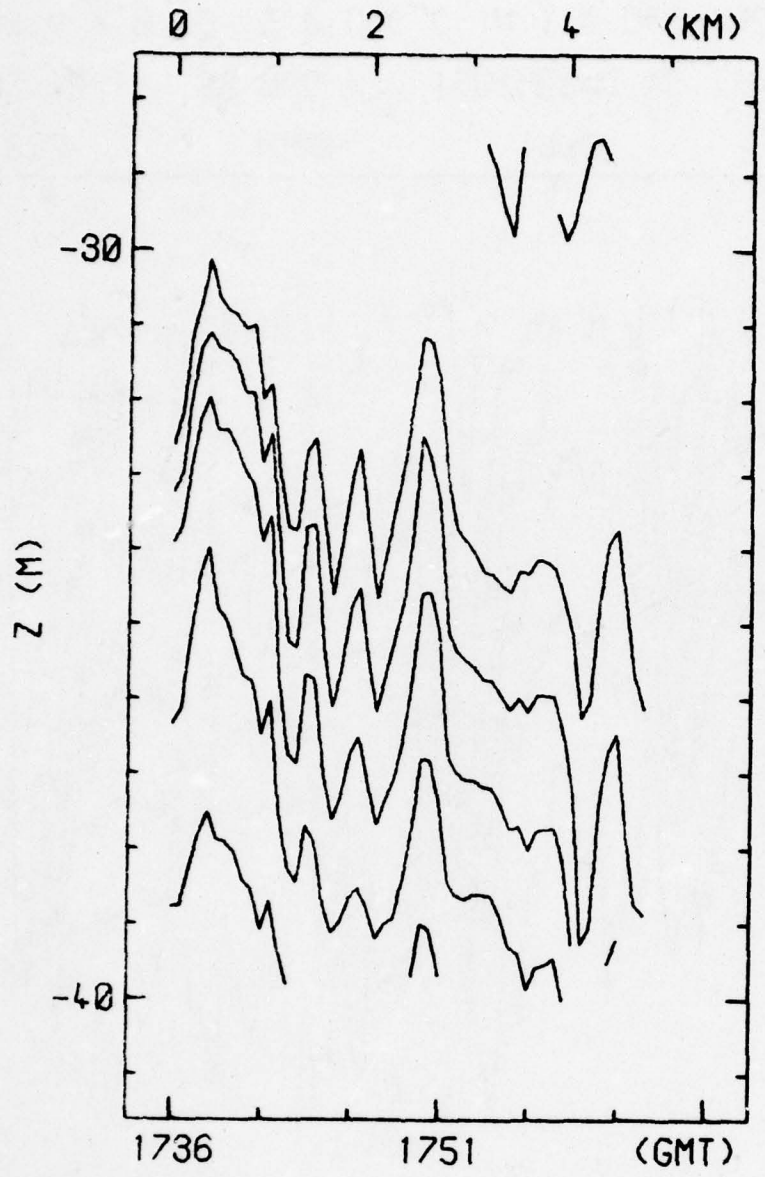
RUN 24 8 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 6.5 TO 12.5 DEG C IN 0.5 DEG INCREMENTS

APPENDIX D

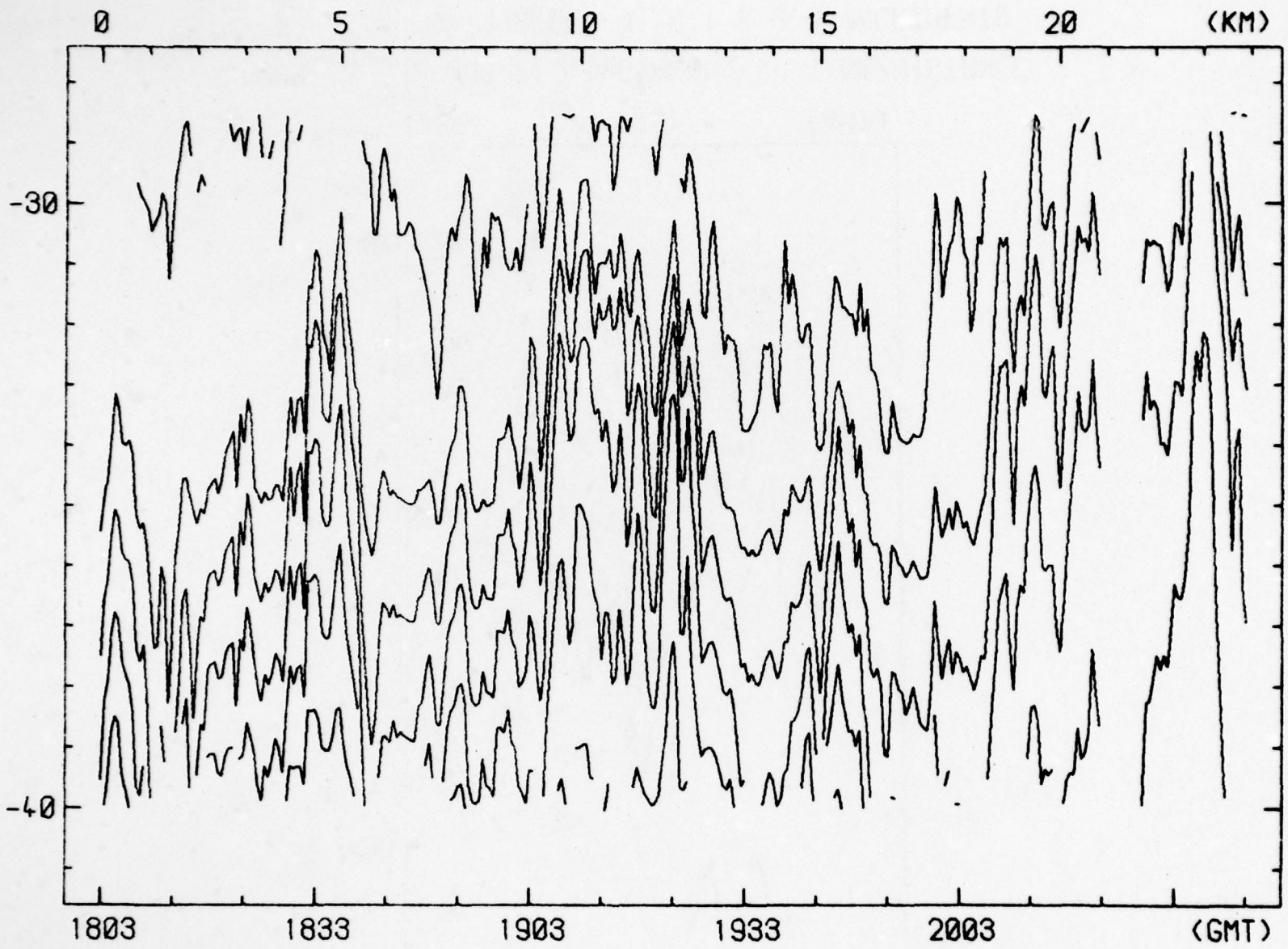
Isotherm Cross-sections, 1.0° Spacing

Isotherm depths, interpolated linearly from the temperature observations shown in Appendix B are plotted on the following pages for selected runs.



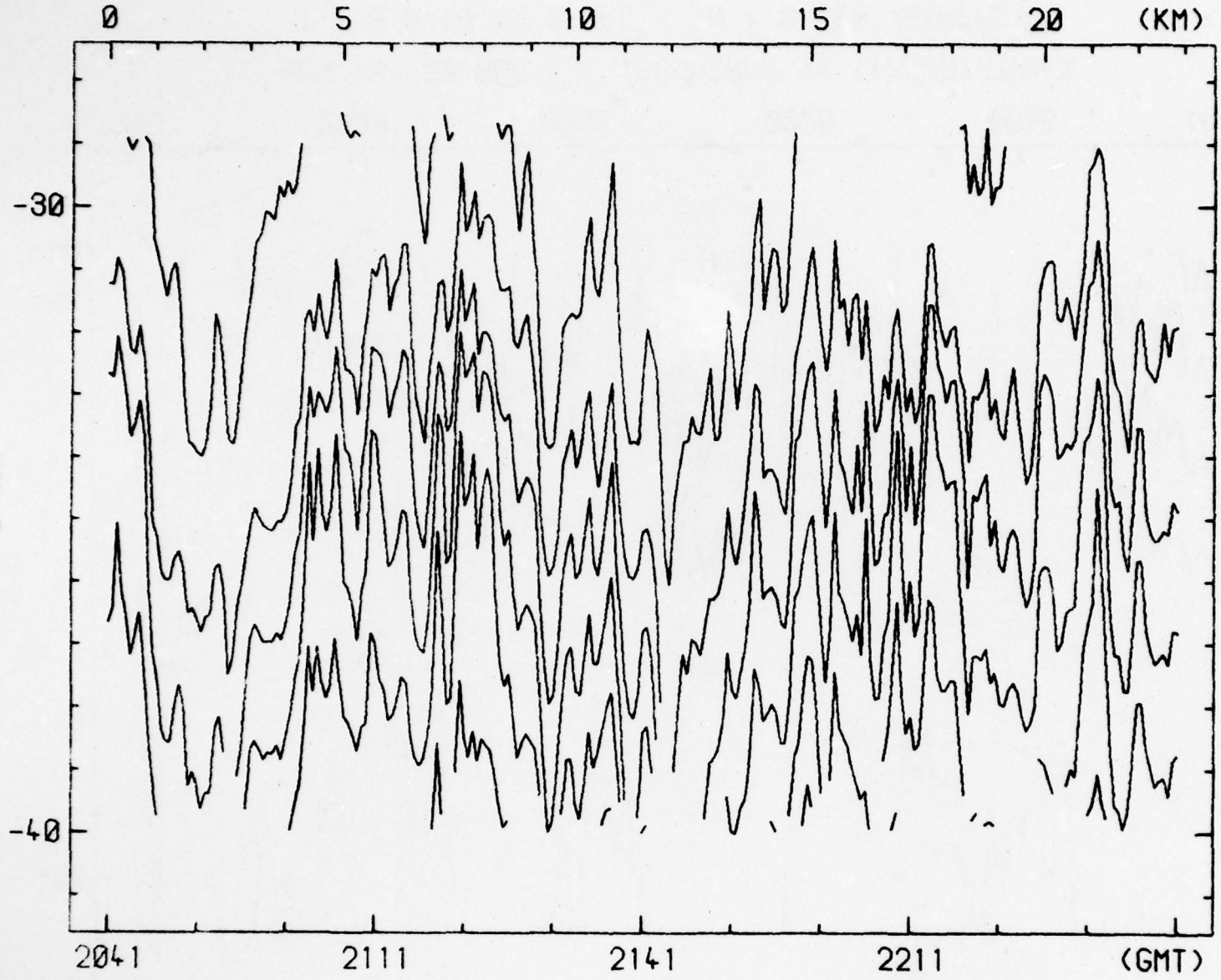
RUN 13 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



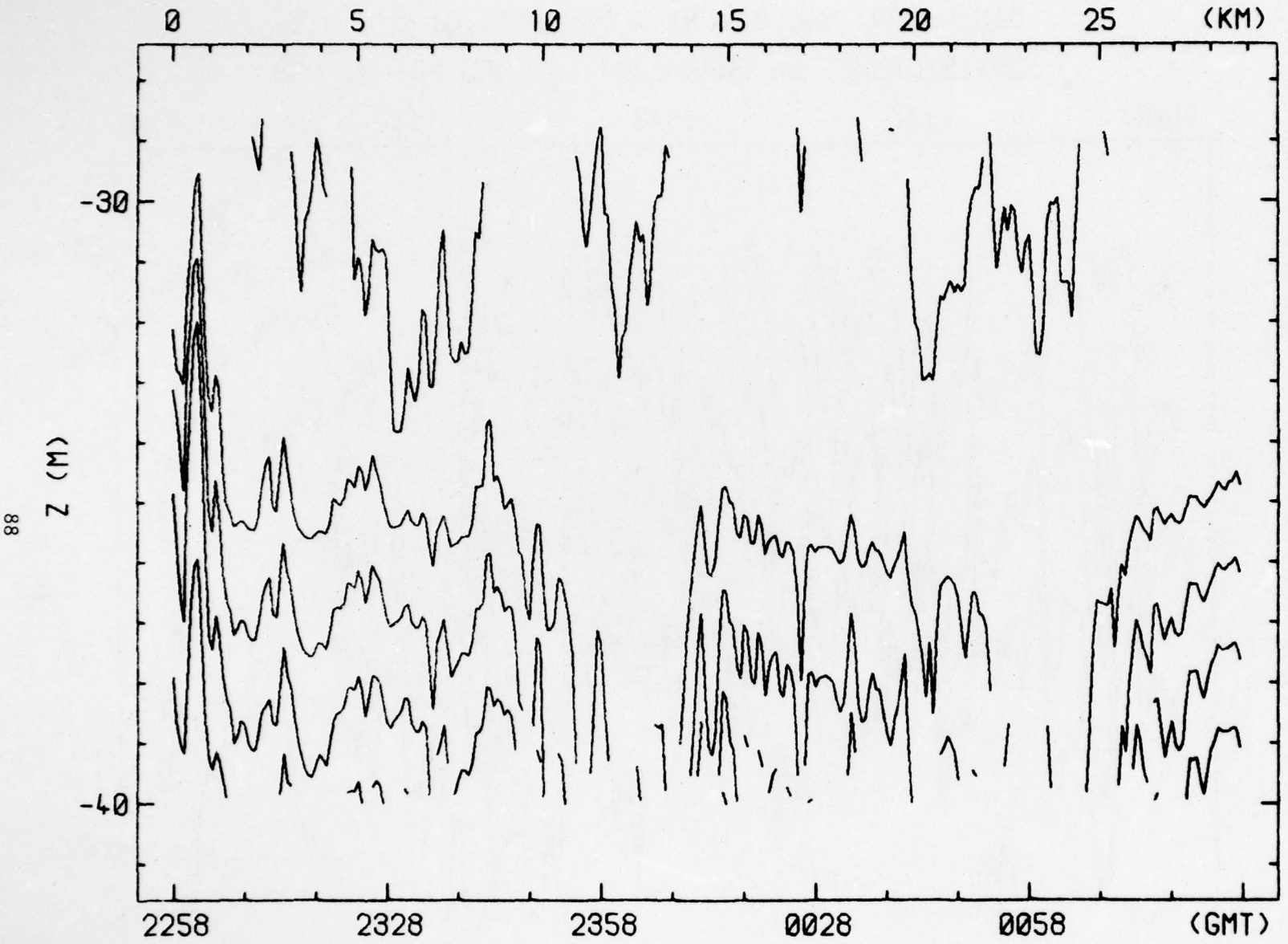
RUNS 13-14 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



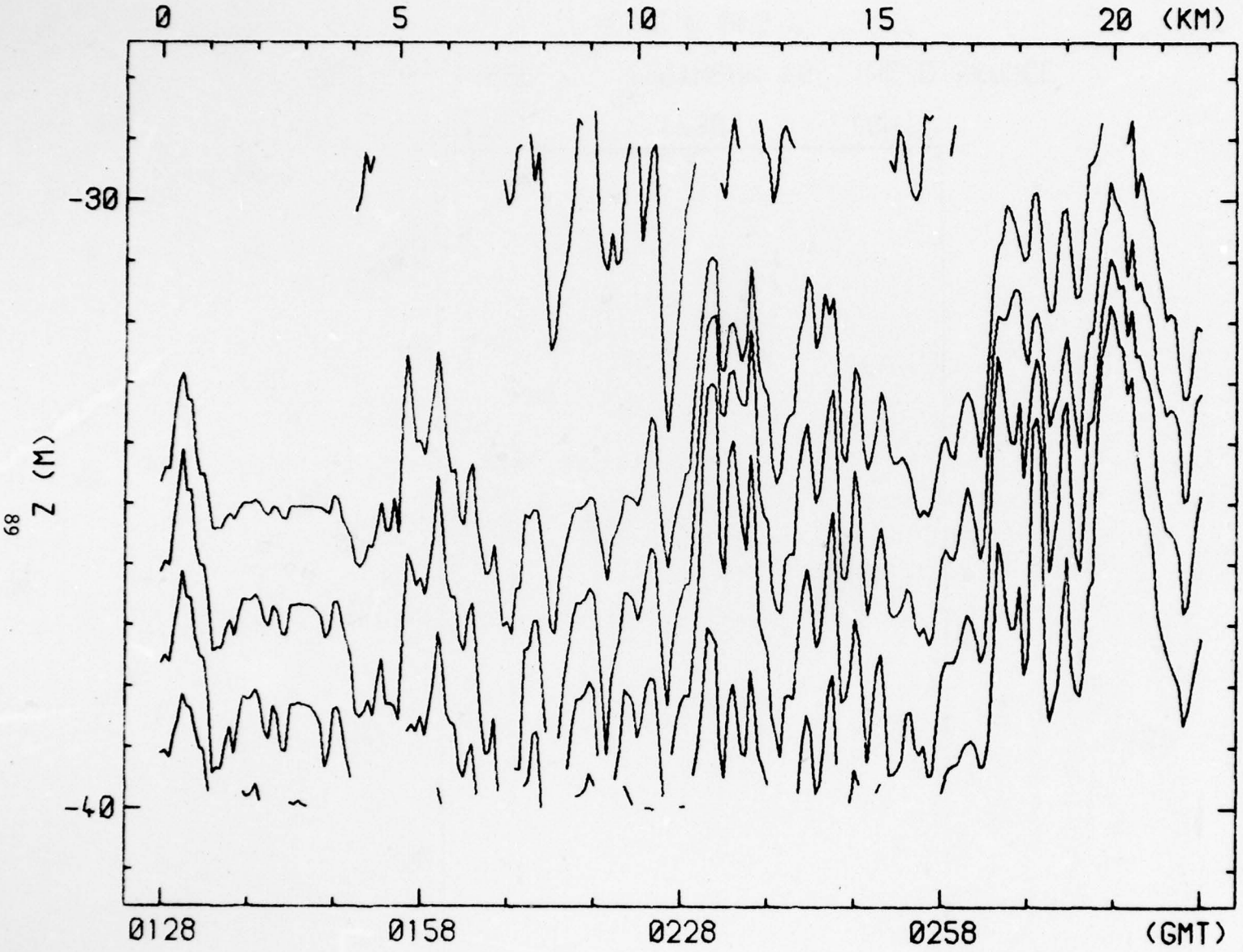
RUN 14 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



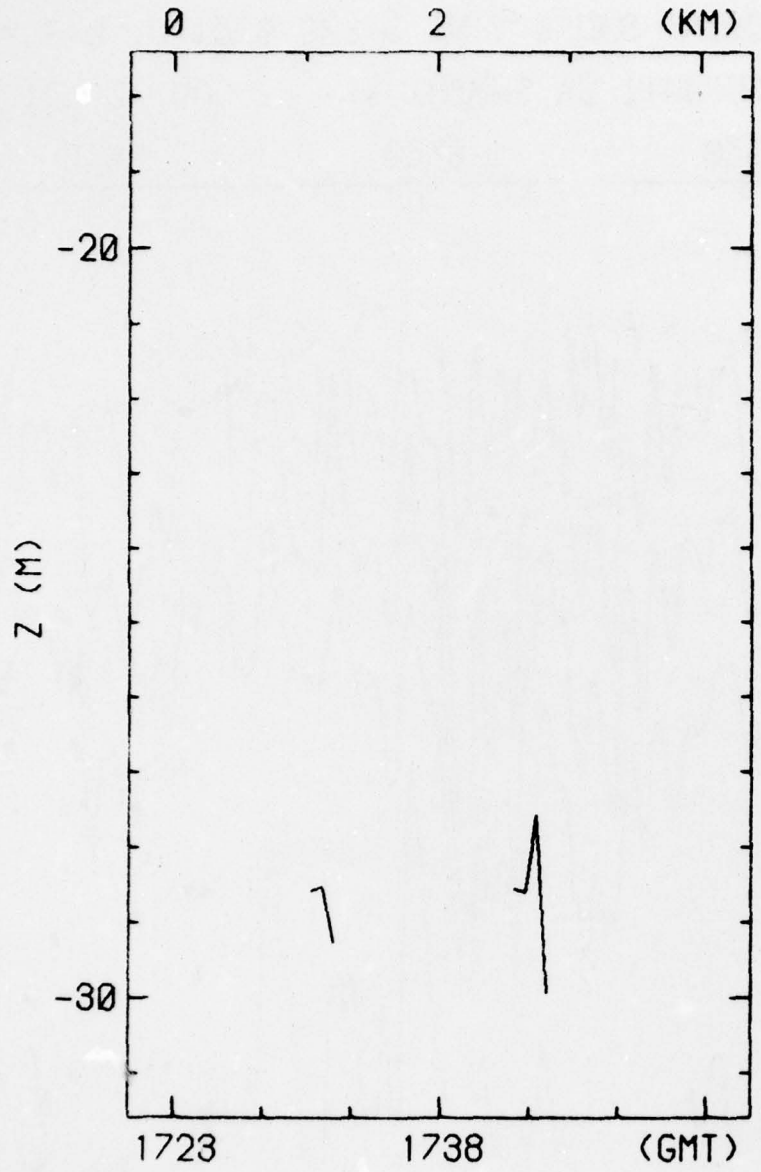
RUN 15 30 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



RUN 15 31 AUG 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



RUN 16 1 SEP 77 ISOTHERM VS TIME/DISTANCE

T = 12.0 DEG C

AD-A074 274 OREGON STATE UNIV CORVALLIS SCHOOL OF OCEANOGRAPHY F/G 8/10
TOWED THERMISTOR CHAIN OBSERVATIONS DURING MILE.(U)
JUL 79 T J SPOERING, C A PAULSON, D DENBO N00014-76-C-0067
UNCLASSIFIED DATA-74 NL

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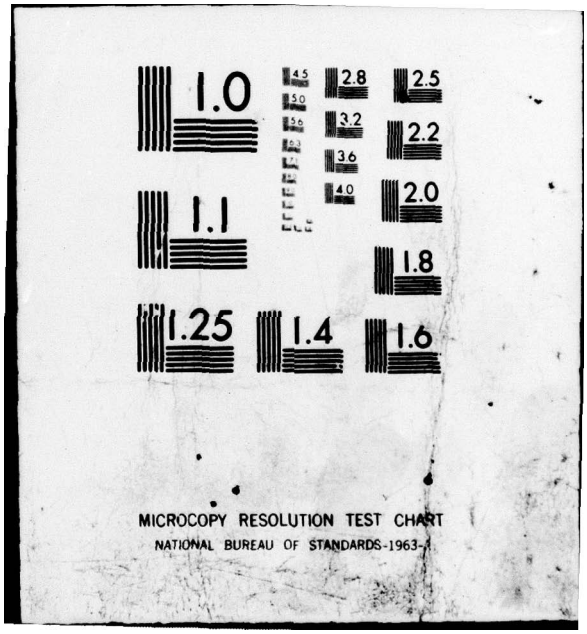
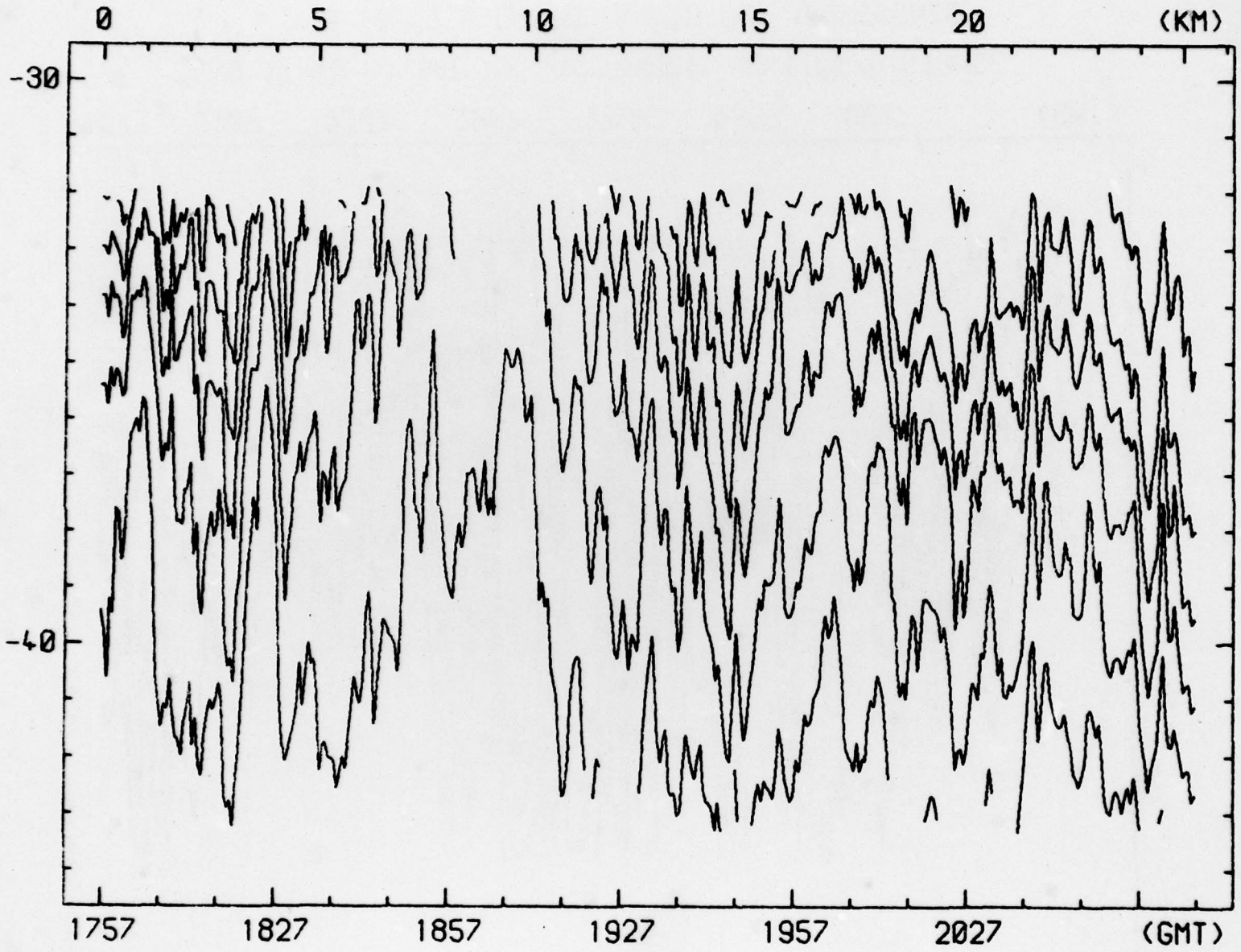
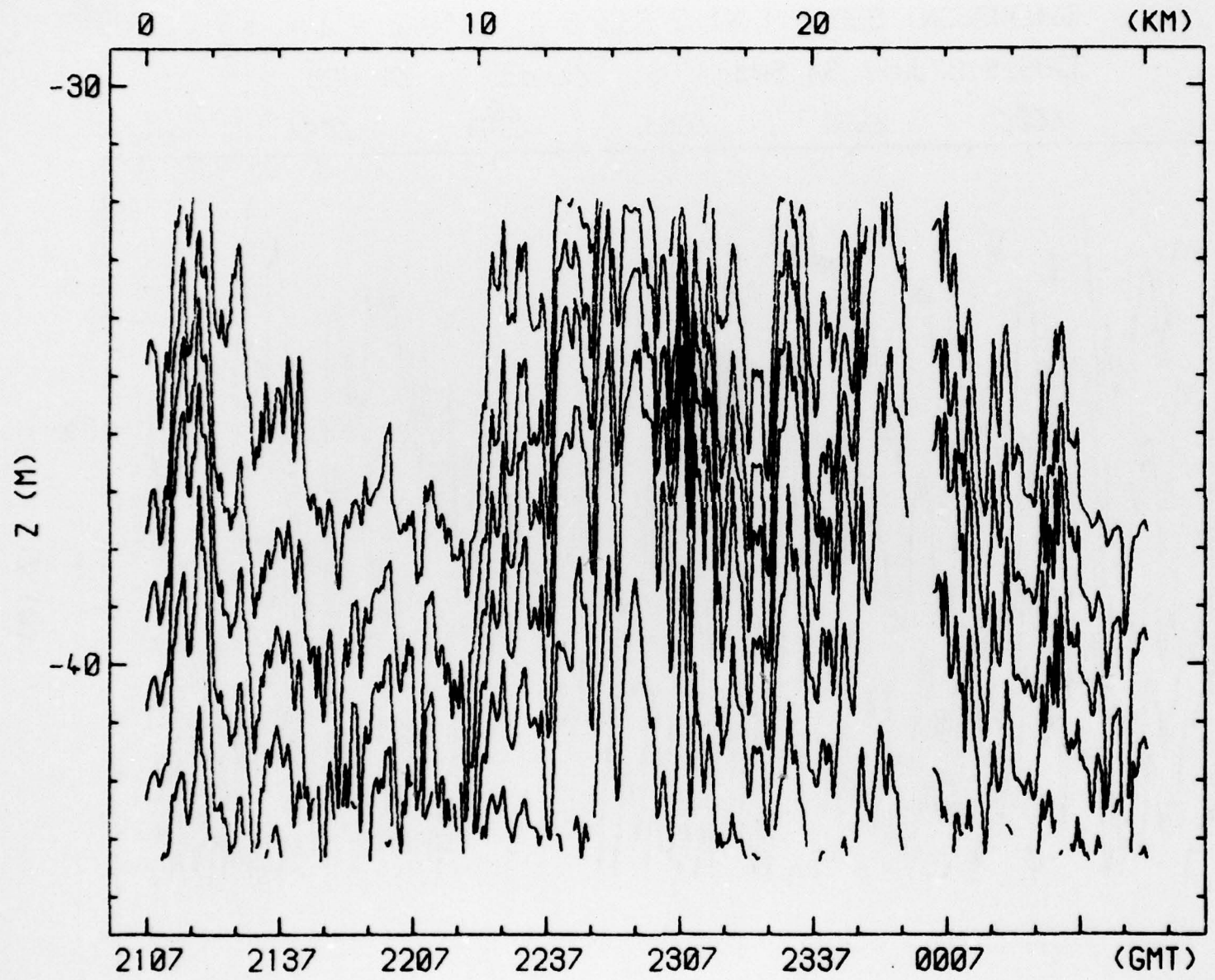

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



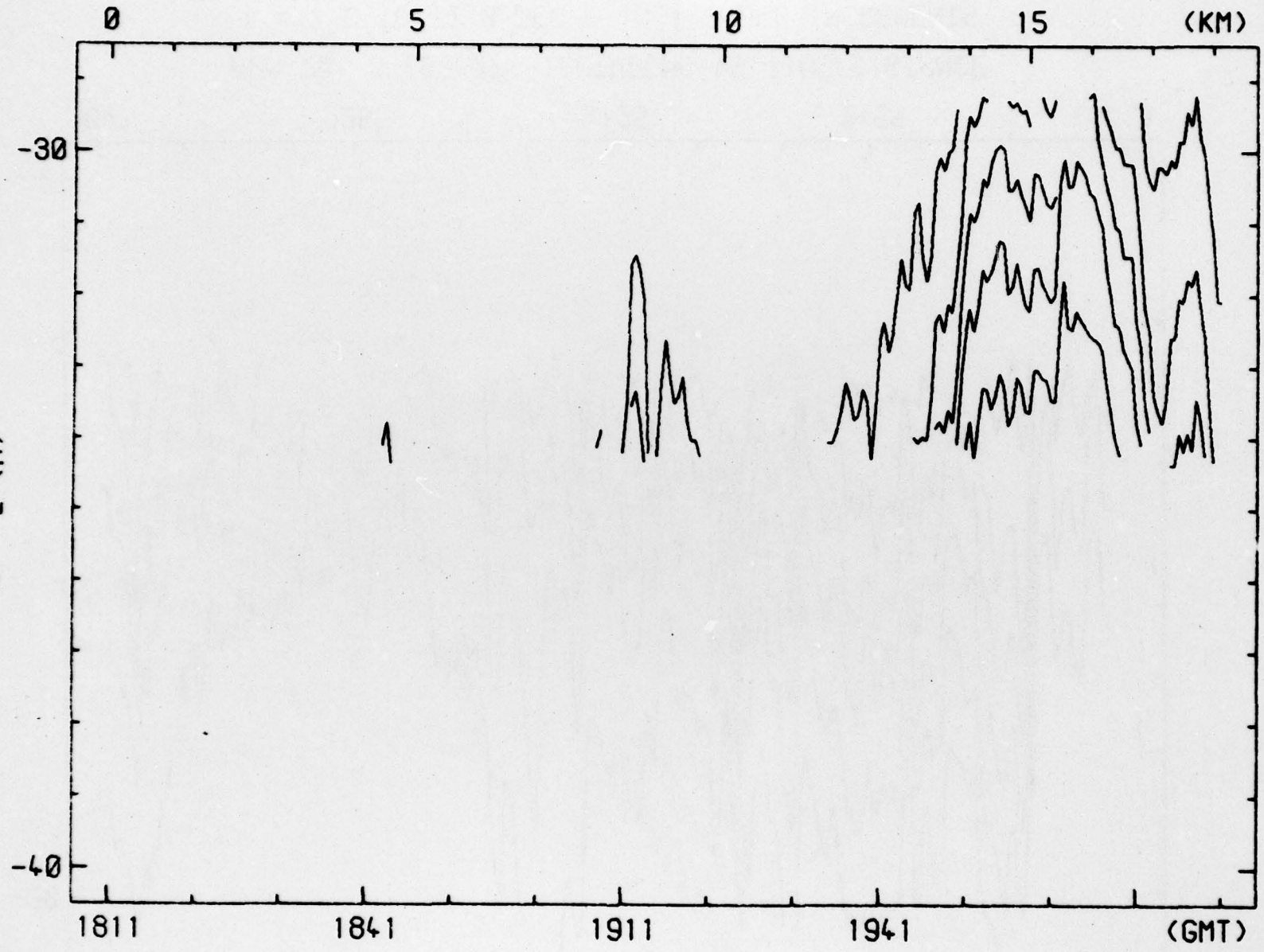
RUN 17 1 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



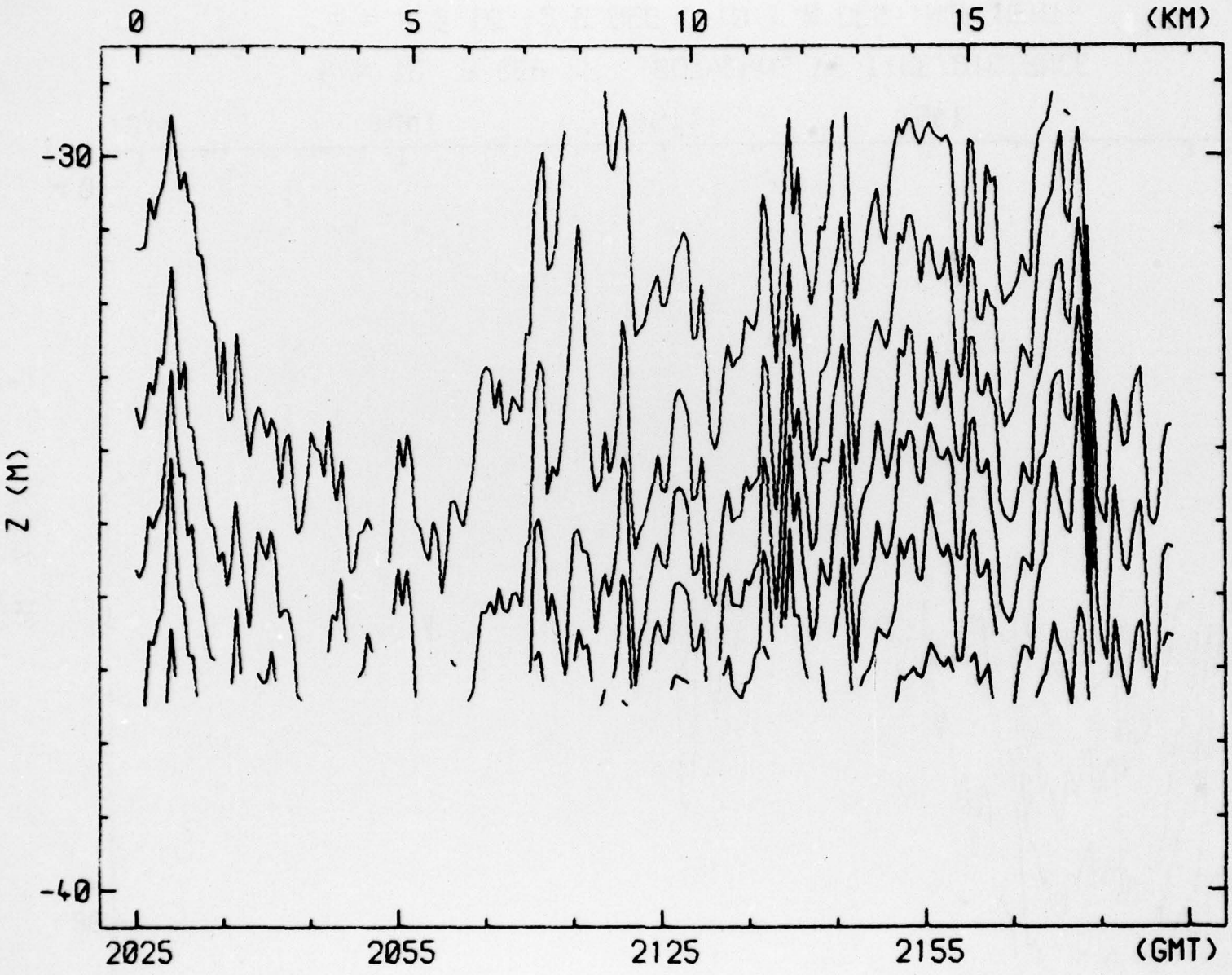
RUNS 17-18 1 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



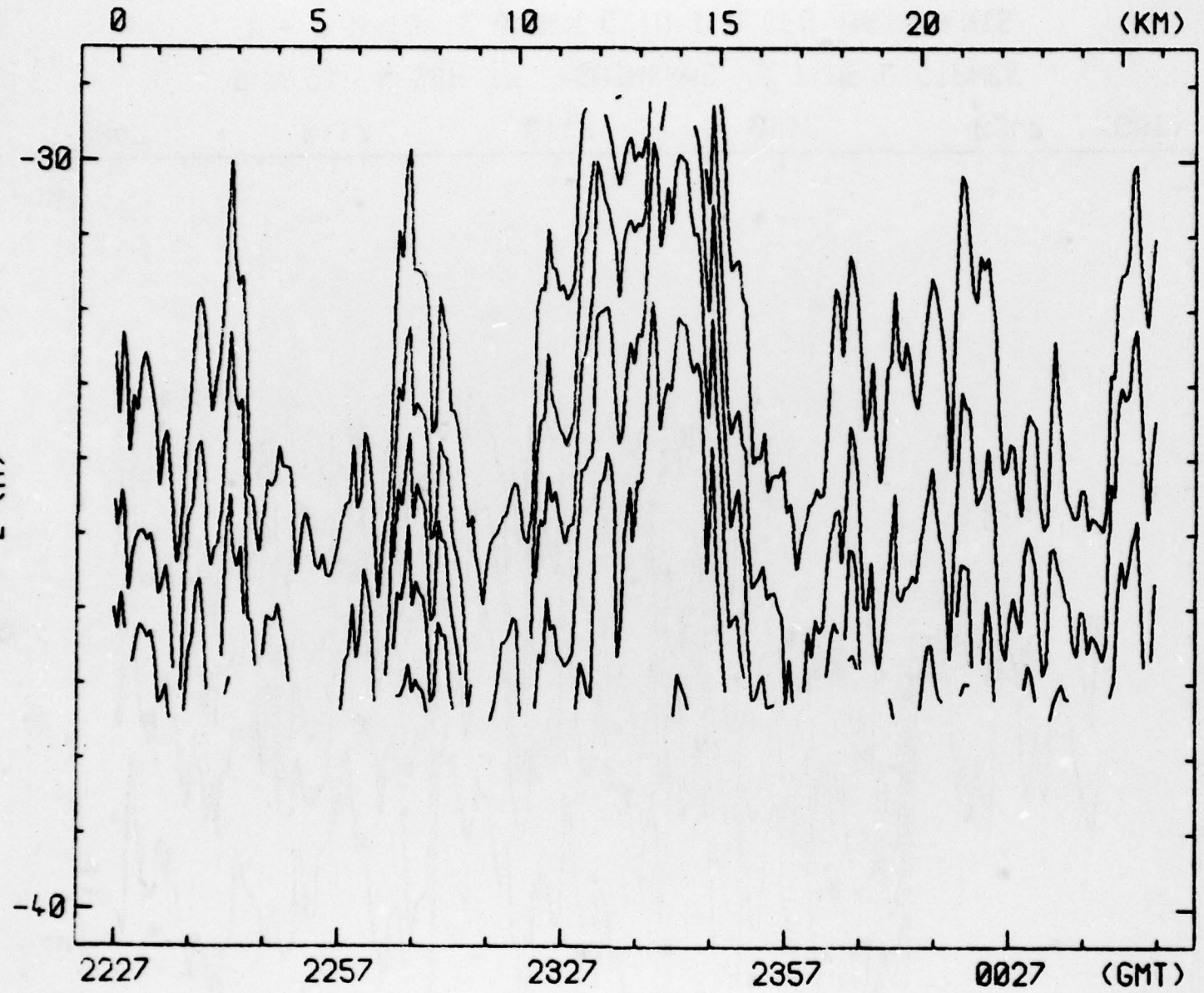
RUN 19 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



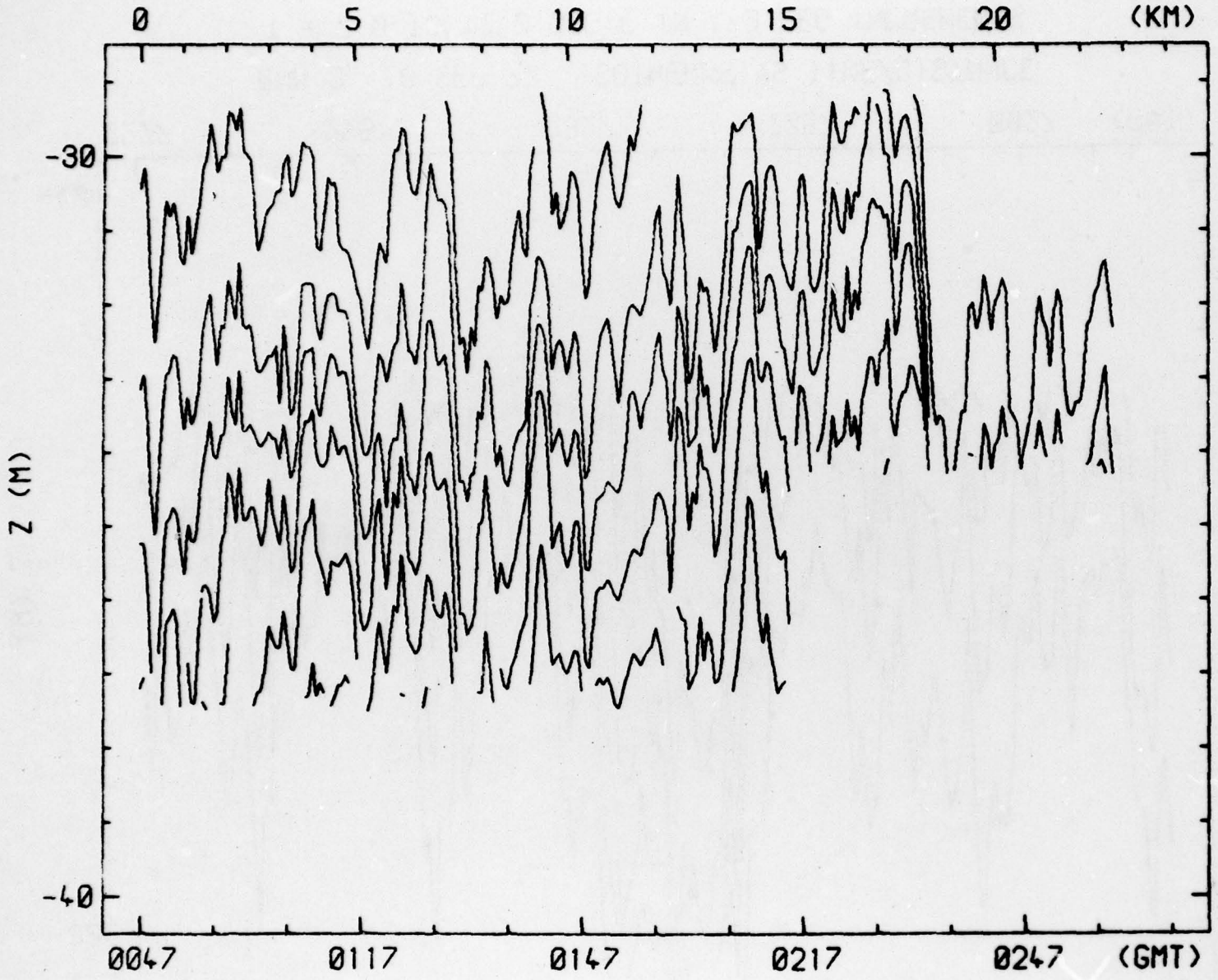
RUN 20 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



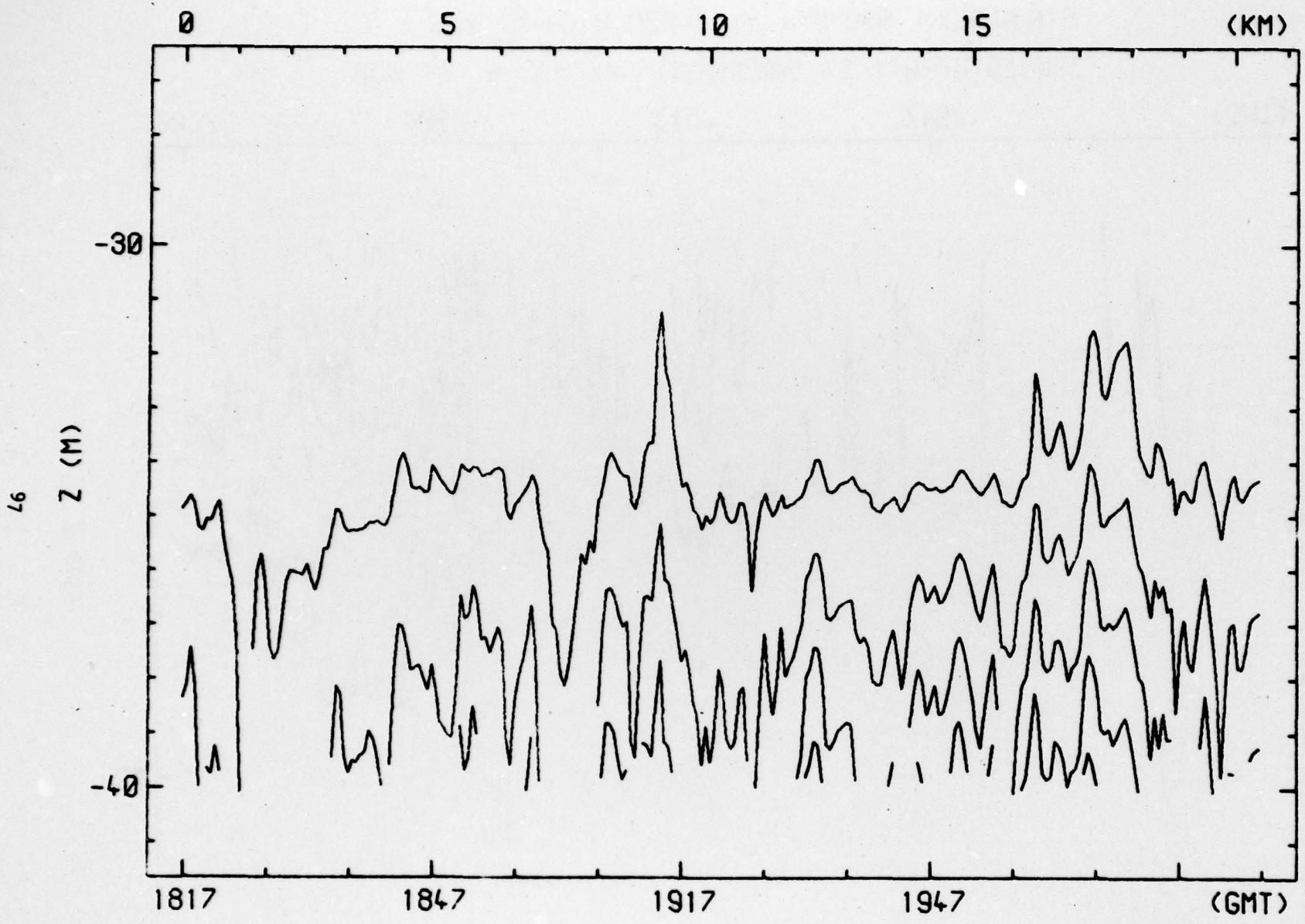
RUN 21 3 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



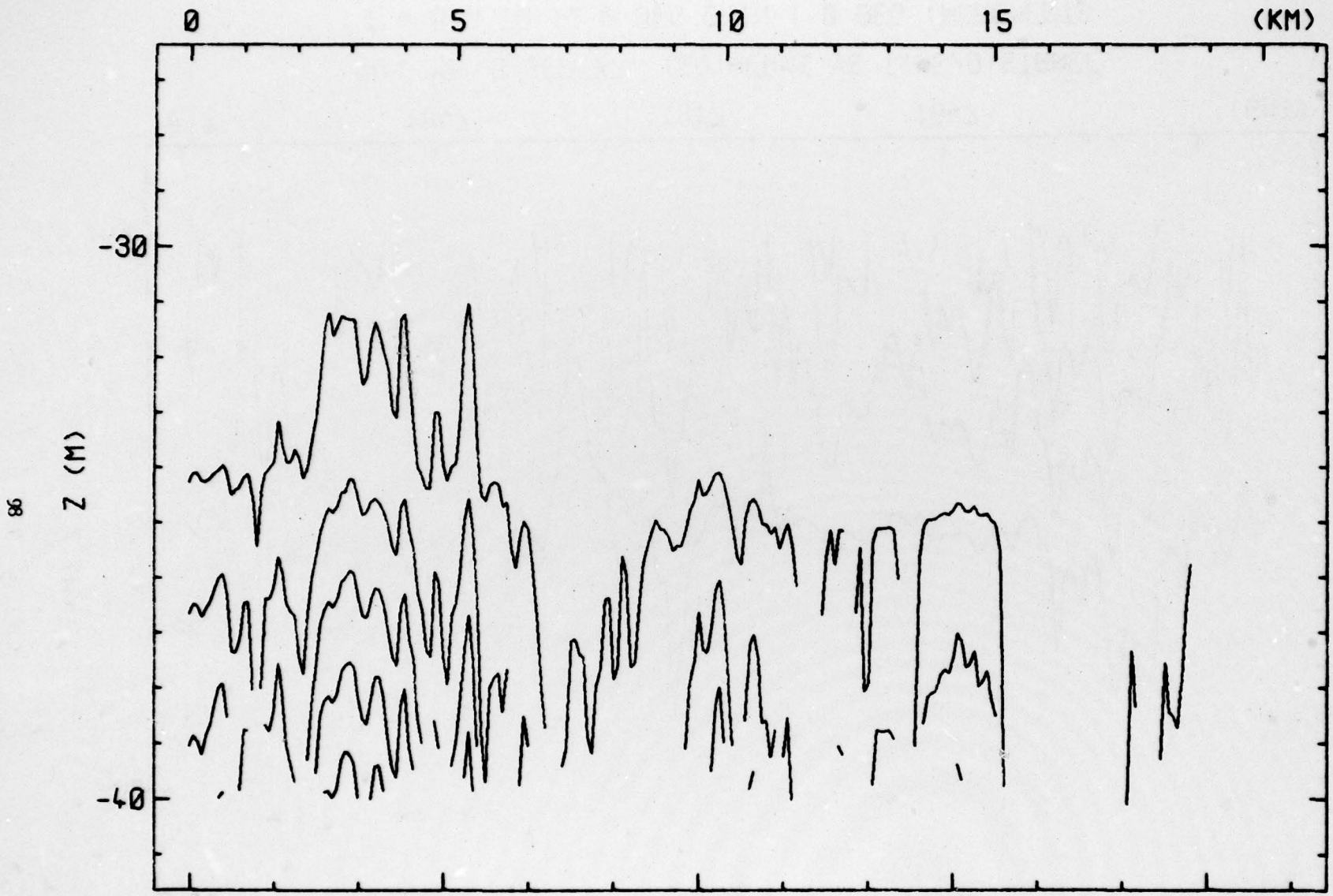
RUN 21 4 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



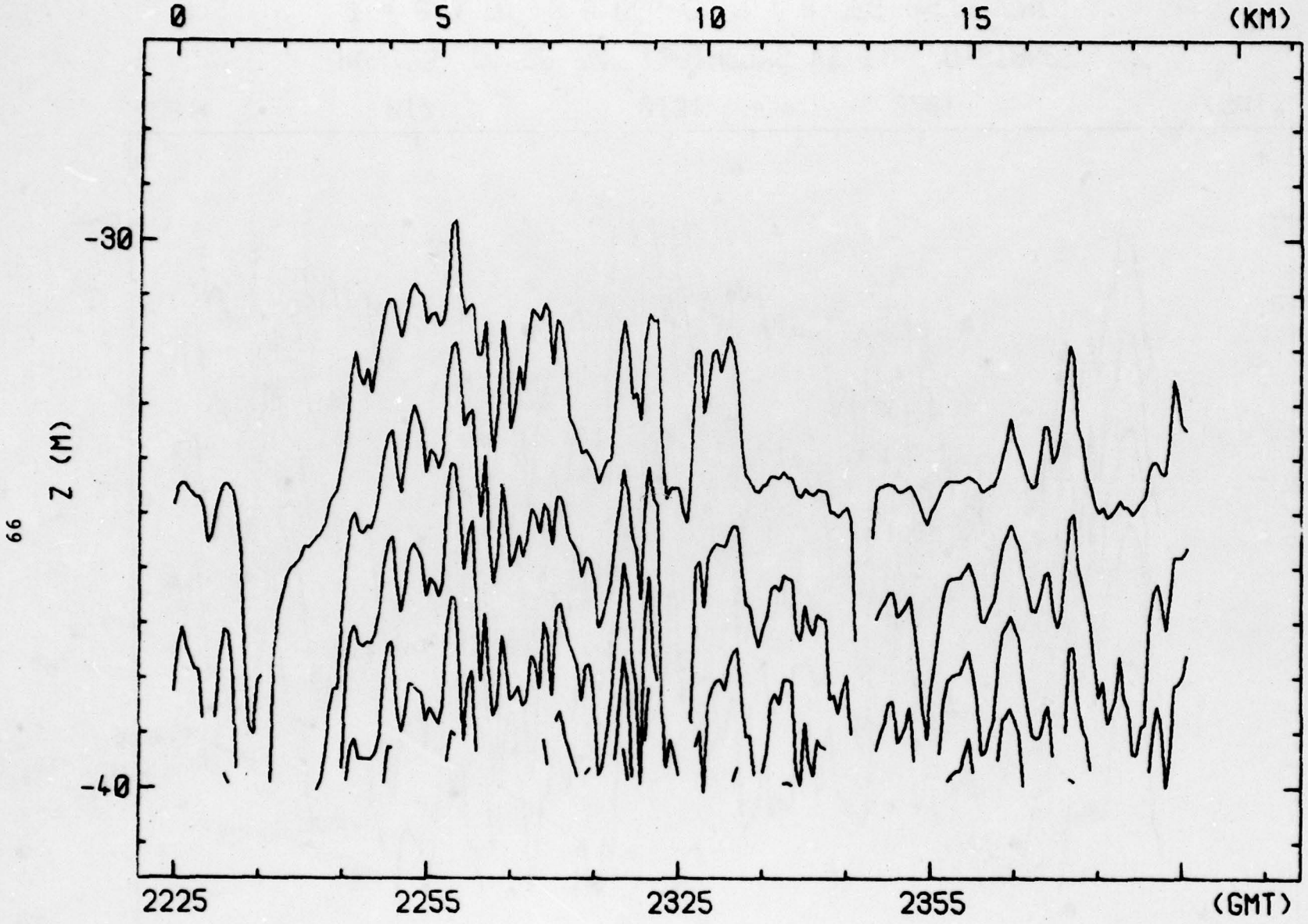
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



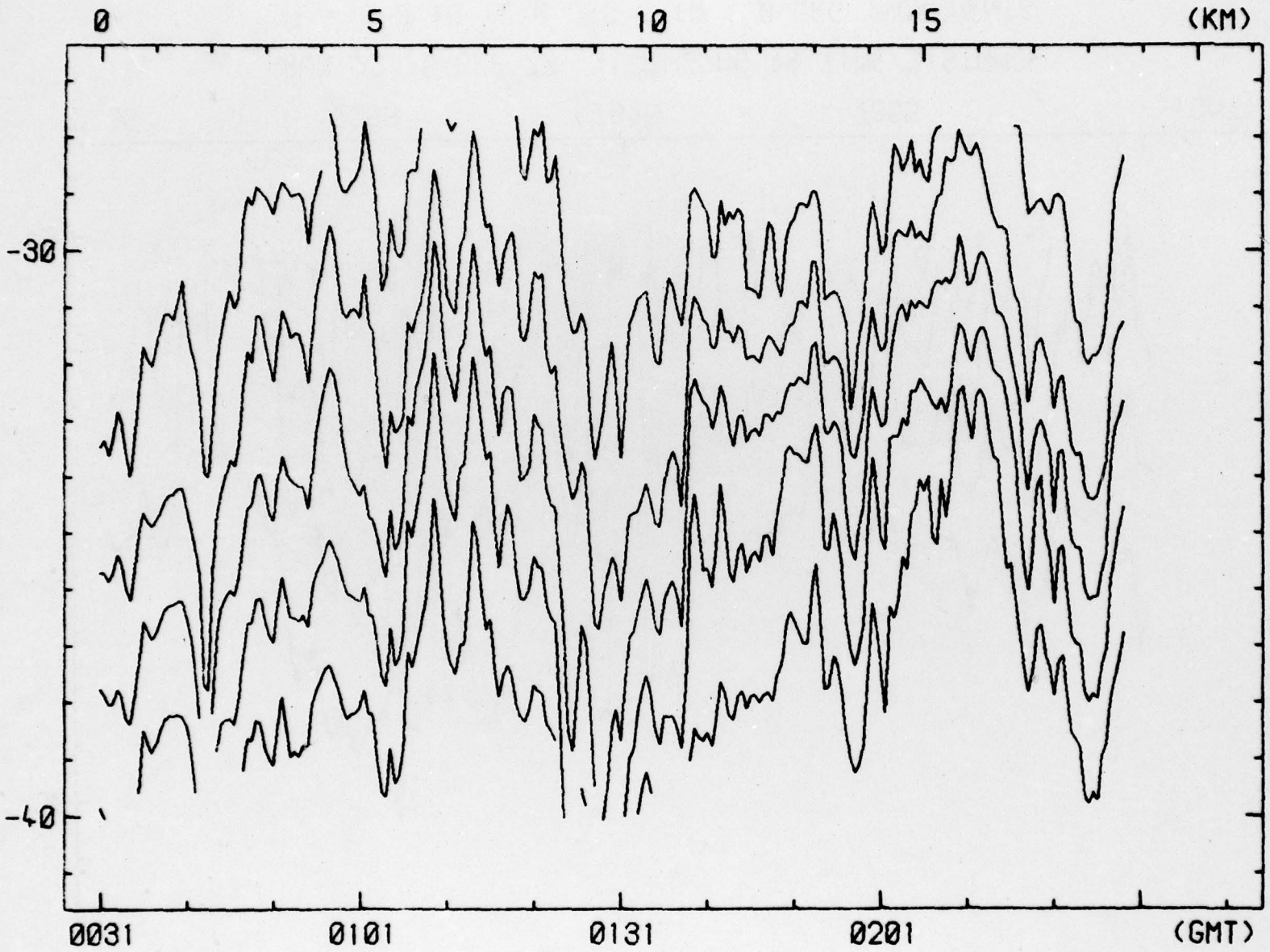
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



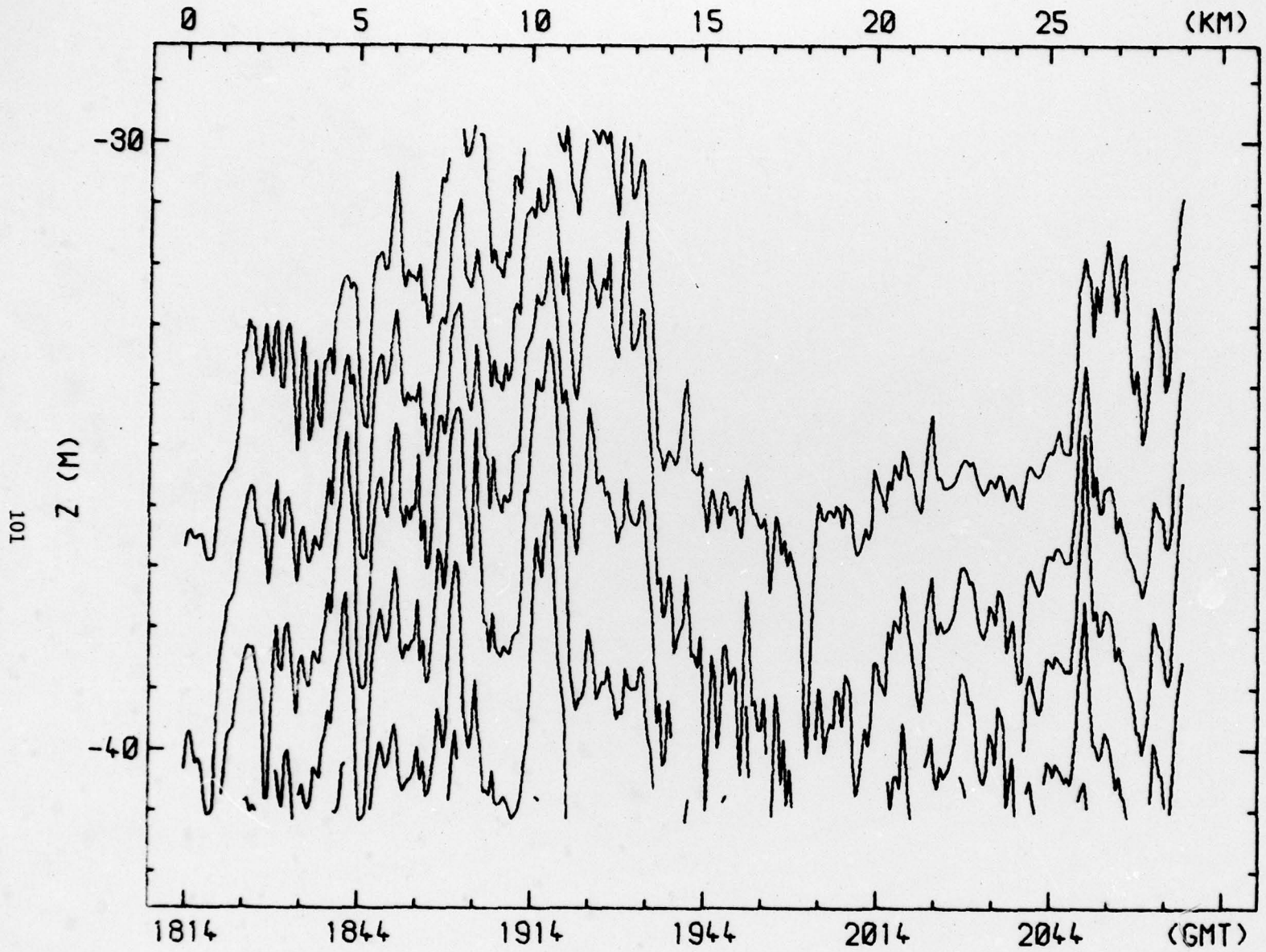
RUN 22 5 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



RUN 23 6 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 8.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS



RUN 24 8 SEP 77 ISOTHERMS VS TIME/DISTANCE

T = 7.0 TO 12.0 DEG C IN 1.0 DEG INCREMENTS